SUPERCONDUCTING SUPER COLLIDER

HEARING

BEFORE THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

SECOND SESSION

MARCH 22, 1988

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SUPERCONDUCTING SUPER COLLIDER

TUESDAY, MARCH 22, 1988

House of Representatives
Committee on Science, Space, and Technology
Washington, D.C.

The Committee met, pursuant to notice, at 1:12 p.m., in Room 2318, Rayburn House Office Building, the Honorable Robert A. Roe, [Chairman of the Committee] presiding.

OPENING STATEMENT OF HON. ROBERT A. ROE, CHAIRMAN, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

The Chairman. Good afternoon, ladies and gentlemen. The Committee will come to order. We are called today for a hearing between 1:00p.m and 5:00p.m to review the status of the SSC.

Before we take testimony here today, I think it would be useful to outline what we intend to accomplish in this hearing, and also explain just what we are having the hearing on the Superconducting Super Collider for.

The purpose of the hearing is review the SSC site selection process, the status of and projections for the SSC magnet development program, and the funding requirements to support both of these activities in the remainder of fiscal 1988 and through fiscal year 1989.

The International Scientific Cooperation Subcommittee held a hearing on international cost-sharing prospects for the SSC on Wednesday of last week. The reasons why we were having the hearing require a bit more explanation. It is timely for us to receive an update of the progress of the SSC project, and there are some immediate matters of controversy before us.

There is Congressional concern both about the States' reaction to the SSC site-selection process and the reprogramming request, which the DOE has transmitted to the Congress. We understand that many States whose proposals did not make the SSC best-qualified list have expressed dissatisfaction with the debriefing conducted by the DOE.

In order to develop a legislative record on this issue, we have asked the DOE and the National Academies of Science and Engineering to testify on the manner in which the site selection process was carried out. The NAS and the NAE Super Collider Site Evaluation Committee provided a Best Qualified List to DOE under the applications of criteria devised by the Department.

The development of the superconducting magnet design appears to be the most critical SSC R&D presently being conducted. We are not only interested in how that magnet work is going, but we must better understand the funding requirements for the remainder of fiscal 1988 and the next fiscal year.

I am told that the Central Design Group is doing an outstanding job of prototype magnet design, fabrication, and testing. However, it is my understanding that, unless the DOE reprogramming goes forward, this talented and most critical group will start laying off people in the very near future.

The magnet development question also, I believe, gives the Committee the opportunity to hear more about what industry might do in the R&D and construction operating phases of the SSC project. In the near term, we are anxious to see industry brought into the magnet development program soon, because ultimately they must manufacture thousands of magnets, as we know.

The Committee is also receptive to any innovative approaches industry might wish to suggest regarding their future involvement. An industry panel will testify on all of these matters.

As most of you know, the DOE has asked for a program of $8 million in unobligated balances to continue magnet development while also completing an evaluation of the seven remaining sites. Both the Senate and the House Appropriations Committee have already denied this request. This Committee has a number of questions regarding the level of existing funding available for magnet R&D and environmental aspects of site evaluation.

We also must understand how the site evaluation process and the cost have been impacted by the DOE's decision to shift the date for preliminary determination of a final site from July to November of this year. I hope we can establish whether the $8 million will be sufficient to carry out all of these tasks through the remainder of fiscal year 1988.

We have at least won a partial victory for the Function 250 before the House Budget Committee, but the fight has just begun. The struggle now shifts to the authorization and appropriation processes in those arenas. This hearing will help us sort out our priorities, at least in part, in space and science as we make policies in these areas.

For our first witnesses we are going to have two members of the Committee, one present member and one former member. But I'm going to hold that up for a minute while I call on additional folks to make their statement.

Now, Manuel Lujan is being honored at a luncheon today and can't be here. He'll be here a little bit later. And, therefore, I personally will present his own statement. He says as follows:

OPENING STATEMENT OF HON. MANUEL LUJAN, JR., RANKING REPUBLICAN MEMBER, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Mr. LUJAN Mr. Chairman, I want to commend you for holding today's hearing on the Superconducting Super Collider.

First of all, I want to emphasize up front that I have been and continue to be a strong supporter of the SSC. And I say this, even though the SSC site proposal in my District in New Mexico did not make the so-called "Best Qualified List" or "BQL."

Having said this, however, I want to express my concerns about the project and the process to date. I requested that the Chairman hold this hearing primarily to explore a number of issues concerning the site selection process itself, which has winnowed the original list of 43 SSC sites in 25 States, submitted to DOE by the September 2, 1987, deadline, to the 7 sites in 7 States on the BQL currently under consideration by the Department of Energy.

This process has been a source of bafflement to myself and many of my colleagues since the issuance of the report of the SSC Site Evaluation Committee of the National Academies of Science and Engineering in December of last year. Furthermore, the debriefings that the New Mexico delegation has received from both the Department of Energy and the Academies have been less than fully enlightening. In fact, there were inconsistencies in the two briefings.

My initial concern has to do with the composition of the Academies' SSC Site Selection Committee and the DOE's role in the selection of that panel. DOE's own statement of work called for "about 15 distinguished scientists, engineers, and other individuals...appointed giving due consideration to potential real or apparent conflicts of interests and geographical distribution." A comparison of this statement of work with the actual size and composition of the Academies' committee raised a number of questions in my mind.

First, if the DOE statement of work called for a committee of "about 15 individuals", how did we end up with 21 members, an increase in size of 40 percent.

Second, a total of 6 committee members were from California, and a seventh member of the committee had recently moved to Princeton after being at the California Institute of Technology for a decade. Essentially, then, 7 of the 21 members, or one-third, were Californians and California had two sites being considered by the committee. How did such a committee composition appear to give "due consideration to potential real or apparent conflicts of interest and geographical distribution?"

That a California site did not make the BQL is beside the point, and does not constitute proof that the process was fair and unbiased. In fact, it could easily be argued that such a large California representation on the committee actually hurt that State's chances because of individuals bending over backwards to demonstrate how "fair and unbiased" they were.

Third, of the total of 21 committee members, only one is from a city or metropolitan area of a population that could conceivably be less than 100,000 people. Many of the SSC proposals were for sites located in rural areas, and it should be noted that all of the sites on the BQL are in the immediate vicinity of metropolitan areas with populations of greater than a million. Was there an inherent bias against rural areas? How did such a committee composition appear to give "due consideration to potential real or apparent conflicts of interest and geographical distribution"?

Fourth, the Universities Research Association, URA, operates Fermilab in Illinois under contract to the DOE. URA is also the DOE operating contractor of the SSC Central Design Group located at the Lawrence Berkeley laboratory. Furthermore, the State of Illinois proposal includes the use of existing facilities at Fermilab.

Ten of 21 committee members have direct affiliations with URA member institutions, and of the remaining 11 committee members, two were for many years on the faculty of URA institutions, and three others either are or were recently associated with a DOE institution operated under contract by a group of URA-member universities. How did such a committee composition appear to give "due consideration to potential real or apparent conflicts of interest"?

In addition to these issues, I have concerns about the overall role of DOE and its contractor personnel in the site selection process, and the lack of documentation of the site selection methodology and process used by both the Academies and the DOE. In particular, the lack of documentation in the application of the geologic and tunneling criteria has been distressing to the New Mexico delegation, because we have been told in the debriefings that our geology was about average. But we have been assured by our experts that our geology is excellent. Yet, the documentation does not exist to support either claim.

These concerns are shared by many of my colleagues. And if the SSC site selection progress is not perceived to be fair and equitable, it will be impossible to achieve the support needed to initiate construction of the project in fiscal year 1989.

As I said at the beginning of the statement, I remain a strong supporter of the SSC, and I hope that today's hearing will address the concerns that a number of us share about the SSC site selection process to date.

The CHAIRMAN. The Chair now recognizes the distinguished gentleman from Texas, the Chairman of our Subcommittee, Mr. Hall.

OPENING STATEMENT OF HON. RALPH M. HALL, CHAIRMAN, SUBCOMMITTEE ON INTERNATIONAL SCIENTIFIC COOPERATION

Mr. HALL. Thank you, Mr. Chairman, and members of the Committee.

Allow me to take the opportunity to report to the Committee on the conclusions of a hearing on the SSC held last week before the Subcommittee on International Scientific Cooperation.

At that hearing, we asked the Department to give us an update on the progress of their discussions with potential foreign participants in the SSC and explore further the basis for the range of estimates that have been coming out of the Department on the levels of foreign support that we might realistically expect.

As you know, press reports have indicated that up to $1.8 billion might be forthcoming and even the Secretary, in testimony before the Energy and Water Appropriations Subcommittee, said that as much as 50 percent of the total cost of approximately $5 billion might be underwritten by foreign and State sources.

Now, these estimates seem awfully high to me and our Subcommittee, especially since a survey, requested by our Subcommittee and conducted by the Congressional Research Service, found that, historically, participation levels in similar "big science" projects have been much lower.

Dr. James Decker, Acting Director of the Office of Energy Research, admitted, Mr. Chairman, at our hearing that the estimates of foreign participation in reality were "guesstimates", and that the Department had no solid commitment for foreign financial support at this time. That was his testimony before our Subcommittee.

This is certainly not surprising, since these discussions are occurring at a time when the Congress has not made a commitment to fund the SSC. In this atmosphere, talk is cheap. And, while I think that the Department has reason to express a certain amount of optimism, the estimates that have been tossed around are not nearly solid enough to be used for budgetary purposes. And that's precisely how these estimates are being used at this time.

It seems to me that, for budget purposes, we have to proceed on the basis that there will be no foreign participation in the project. Now, while this will require the political courage to appropriate the full amount of funds required to build the project, it doesn't mean that we have to actually spend them. If foreign contributions are forthcoming on terms and conditions that are acceptable—and that's very important—then these contributions can back out the dollars that have been appropriated. It will certainly be easier not to spend money after it's been appropriated than to appropriate additional money to fill in a funding gap due to unrealistic and excessively optimistic estimates.

This approach has two benefits. One, it sends a message to all potential foreign participants that the U.S. Government is committed to building and operating the SSC. And, secondly, it puts this Government in a position of strength to accept those offers of contributions that best fit with our overall national objectives and to negotiate the terms and conditions of their acceptance.

Now, Mr. Chairman, while we're considering foreign participation, I think it's also important that we consider what the States are offering in the way of financial incentives, if we're truly serious about reducing the Federal outlays. My State of Texas put together a package of about $1.1 billion, consisting of revenue and general obligation bonds, issuance of which has been approved by the voters, pledges of public and private contributions, and in-kind services. I understand other States have put together similar incentive packages.

The Domenici amendment prohibits the Department from considering State contributions during the site selection process, and has directed that the States submit their incentive packages in sealed envelopes that will be opened upon selection of the site. Now, with the budget problems that we have, we no longer have the luxury of being able to ignore the State contributions, since they'll be truly significant.

Mr. Chairman, I appreciate the opportunity to discuss the matter with the Committee and to assure you that our Subcommittee will continue its oversight so that the Department does not compromise the SSC with well-meaning but overzealous and unrealistic promises of foreign participation.

I yield back the balance of my time.

The CHAIRMAN. I understand you have to go to another mark-up hearing. The Chair recognizes the lady from Tennessee.

OPENING STATEMENT OF HON. MARILYN LLOYD, CHAIRMAN, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mrs. LLOYD. I want to thank the Chairman for calling the hearing today, and ask unanimous consent that my opening statement be made a part of the record.

The CHAIRMAN. No objection. So ordered. The Chair recognizes the singular gentleman from New York, Mr. Boehlert.

[The prepared opening statement of The Honorable Marilyn Lloyd follows:]

HON. MARILYN LLOYD
STATEMENT
SUPERCONDUCTING SUPER COLLIDER
MARCH 22, 1988

MR. CHAIRMAN, I WOULD ADD MY VOICE TO YOU AND OTHER MEMBERS OF THE COMMITTEE WHO BELIEVE THAT THE SUPERCONDUCTING SUPER COLLIDER (SSC) IS AN IMPORTANT ADDITION TO THE UNITED STATES SCIENCE RESEARCH ARSENAL. HOWEVER, I MUST SAY THAT I OFFER MY SUPPORT WITH SOME SERIOUS RESERVATIONS. ALTHOUGH MY STATE IS ONE OF THE FINALISTS SELECTED BY THE NATIONAL ACADEMY OF SCIENCES ADVISORY PANEL, I FEEL THAT IT IS MY OBLIGATION TO BRING TO THE ATTENTION OF ALL OUR MEMBERS THAT THERE WILL BE SOME SERIOUS QUESTIONS TO BE ANSWERED BEFORE THE SSC CAN BE FULLY AND COMPLETELY SUPPORTED.

THE REALITIES OF THE BUDGET PROCESS SUGGEST THAT FINDING THE NECESSARY RESOURCES OVER THE NEXT SEVEN YEARS OR SO THAT WILL BE REQUIRED TO BUILD THE SSC WILL BE A MAJOR PROBLEM. AS CHAIRMAN OF THE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT, I HAVE BEEN PARTICULARLY IMPRESSED BY THE FACT THAT SEVERAL NEW SCIENTIFIC ENDEAVORS ARE FACING THE NEED FOR INCREASED FUNDING RESOURCES IN ORDER TO BUILD NEW FACILITIES TO MEET THE DEMANDS OF OUR EVER GROWING KNOWLEDGE BASE. SOMEHOW OVER THE NEXT DECADE WE WILL HAVE TO BE ABLE TO FIND THE RESOURCES TO BUILD THESE NEW FACILITIES, AND WE ARE ALL AWARE THAT THE ELECTORATE WILL NOT TOLERATE ESCALATING BUDGET DEFICITS. THESE SITUATIONS WILL CERTAINLY IMPACT POLITICAL DECISIONS

RELATING TO THE CONSTRUCTION OF THE SSC. COMPETITION FOR INCREASINGLY SCARCE FEDERAL FUNDS FOR SCIENTIFIC RESEARCH ENTERPRISES IS FIERCE.

I AM CONCERNED THAT IT WILL BE IMPOSSIBLE TO DEFEND AN INVESTMENT OF SUCH SCARCE RESOURCES IN A SINGLE ENTERPRISE SUCH AS THE SSC IF SUCH AN INVESTMENT WILL SERIOUSLY IMPACT OUR ABILITY TO SUSTAIN MEANINGFUL FUNDING FOR OTHER IMPORTANT SCIENTIFIC ENTERPRISES. I THINK THIS IS THE CENTRAL ISSUE THAT MUST BE CONSIDERED AS WE PROCEED FURTHER IN OUR DEBATE ON THE MERITS OF THE SSC. I HAVE EVERY CONFIDENCE THAT THE SCIENTISTS AND ENGINEERS INVOLVED IN THE DESIGN OF THE SSC ARE INDEED CAPABLE OF SOLVING THE RATHER FORMIDABLE TECHNICAL PROBLEMS FACING THE PROJECT. I AM LESS CONCERNED ABOUT WHETHER OR NOT SOLUTIONS CAN BE FOUND TO THE CONSTRUCTION OF THE LARGE DIAPOLE SUPERCONDUCTING MAGNETS AN ISSUE THAT I UNDERSTAND WILL BE DEBATED HERE TODAY. I ALSO DO NOT QUESTION THAT THE RESEARCH THAT WOULD BE UNDERTAKEN ON THE SSC WOULD BENEFIT A LARGE SEGMENT OF OUR SCIENTIFIC POPULATION AND MANY OF OUR UNIVERSITIES WHO WOULD PARTICIPATE IN THE RESEARCH INVESTIGATIONS THAT WOULD BE ENABLED BY CONSTRUCTION OF THE SSC.

INDEED, I DO NOT QUESTION THE SCIENTIFIC MERITS OF THE SSC. MY CONCERNS ARE ABOUT PRIORITIES, AND WHETHER OR NOT THE SSC WILL END UP BEING THE "BLACKHOLE" OF OUR FUNDING RESOURCES FOR SCIENCE INVESTIGATION, SUCKING UP ALL AVAILABLE RESOURCES TO THE POINT THAT OTHER SCIENTIFIC ENTERPRISES WOULD BE JEOPARDIZED. THIS WOULD BE AN INTOLERABLE SITUATION AND ONE THAT WE MUST NOT ALLOW TO HAPPEN.

I BELIEVE THAT THE ADVOCACY FOR THE SSC MUST BE FOUND NOT ONLY WITHIN

THE HIGH ENERGY PHYSICS COMMUNITY. OTHER SIGNIFICANT SEGMENTS OF OUR CONSTITUENCIES NEED TO EXPRESS THEIR VIEW THAT THE SSC IS INDEED WORTH THE INVESTMENT. CLEARLY WE ARE BEGINNING TO HEAR SOME OF THESE VOICES FROM INDUSTRY BUT WE ARE YET TO GET A GOOD HANDLE ON WHETHER OR NOT THE PUBLIC WILL STAND FULLY BEHIND THIS PROJECT DURING THE DECADE OF INVESTMENT REQUIRED TO COMPLETE CONSTRUCTION OF THIS ACTIVITY. THE WORSE THING THAT COULD HAPPEN IS THAT WE BEGIN A PROJECT OF THIS MAGNITUDE ONLY TO END UP LACKING THE RESOURCES AND THE PUBLIC WILL TO COMPLETE THE ENTERPRISE.

I THEREFORE AGREE WITH THE CHAIRMAN THAT THERE MUST BE NO DOUBT THAT THE PROCESSES USED IN THE SITE SELECTION, AS WELL AS THE PROCESSES TO BE USED IN SELECTING AND IMPLEMENTING CONTRACTORS TO THE PROJECT, ARE ABOVE REPROACH. I AM CERTAIN THAT THESE MATTERS WILL BE DISCUSSED NOT ONLY IN TODAYS HEARINGS, BUT ALSO IN FUTURE HEARINGS ON THE SUBJECT.

OPENING STATEMENT OF HON. SHERWOOD BOEHLERT, RANKING REPUBLICAN MEMBER, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

Mr. BOEHLERT. Thank you, Mr. Chairman. I recognize that you've called this hearing to address some specific questions about site selection and other issues. But I think we'd be remiss if we didn't acknowledge the context in which this discussion is occurring.

To put it bluntly, hearings on the SSC are becoming exercises in purely theoretical physics. The budget deficit and the paring of the list of potential sites have combined to make the SSC an extremely low priority for most Members of Congress, many of whom view the SSC as a massive public works project rather than a major scientific initiative.

The action by the Budget Committee last week should leave no one in doubt about that fact. At this rate, the SSC will end up reminding Americans not of the thrilling frontiers of space exploration but, rather, of such uninspiring failures as the Second Avenue subway in New York City—a long empty tunnel that is a monument to poor planning and unrealistic budgeting.

It need not be that way. The key to reviving this valuable project is international cooperation.

The United States simply can't afford to undertake big science projects on its own. We must learn to cooperate, as our allies have. That is, as our economic competitors have.

So far, the Department of Energy has paid nothing more than lip service to this notion. Running around the world, hat in hand, expecting other nations to pay for a project over which they will have no control is not international cooperation. Running around Washington, tossing off escalating, yet baseless, estimates of foreign funding is not international cooperation.

You are all, I am sure, familiar by now with my favorite example of what does constitute international cooperation, a transporter site with Canada. There are, no doubt, other examples as well.

But the Department's stubborn refusal even to consider that site—and the concomitant pledges of Canadian support—make suspect all its subsequent pronouncements on cooperation.

With the ratification of the U.S.-Canada Free Trade pact, protons will become the only items unable to cross our northern border unimpeded.

It's true, of course, that genuine international cooperation raises issues and obstacles that "going it alone" avoids. But adjuring such cooperation will result in an even greater obstacle. It will be well nigh impossible to pay for the thing.

It's understandable, perhaps, for Departmental officials to want to attack the scientific frontier as so many other American frontiers have been confronted—solo, the rugged cowboy riding off alone. But, Mr. Chairman, the cowboy's level of subsistence didn't allow for much in the way of $6 billion pieces of equipment.

It's time our attitudes caught up with our needs.

Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the singular gentleman from California, Mr. Brown.

OPENING STATEMENT OF HON. GEORGE E. BROWN, JR., THE REPRESENTATIVE IN CONGRESS FROM THE 36TH DISTRICT OF THE STATE OF CALIFORNIA

Mr. Brown. Mr. Chairman, I hesitate to take the Committee's time, but I will anyway.

[Laughter.]

Mr. Brown. Two weeks ago I visited CERN on an individual trip and had a chance to look at the facilities and talk to Dr. Rubbia. It was rather a startling experience, and I know many members of the Committee have also visited the site and perhaps shared my feelings about it.

First of all, it is a cross-national site, which I think Mr. Boehlert probably knows already. But it seems to be working very well. Most of the geography os the ring itself is in France, although the headquarters are in Switzerland.

The tunneling operation over there probably undergoes a more difficult terrain or penetrates a more difficult terrain than any of the sites selected in the United States. And I think, probably, the location practically within the city of Geneva, at least adjoining the airport, poses more problems than any U.S. site would.

So, I raise these points to make the issue that I think that the site selection process that the SSC has undergone here is probably as rigorous and as fair and as sensitive to the problems that could arise as any site selection process could be. And that we shouldn't focus our major attention on that, although, of course, it is important that we assure the public and the political community that the process has been fair and rigorous.

I might say, also, that somewhat to my surprise I found Dr. Rubbia enthusiastic in his support for the U.S. proceeding with this, and as what you might call almost a competitor. I wasn't sure that he would feel that way.

He pointed out with a large supply of well-developed charts that U.S. spending for high energy physics is still below that of Europe and many individual European countries, in terms of proportion of dollars to Gross National Product per capita. That surprised me, because I always thought of ourselves as the big spender in high energy physics.

I think the important issues that we need to consider here, basically, are whether or not we can fund this without making too many sacrifices for other science projects, a point which Mr. Ritter will touch on, and whether or not we have devoted sufficient effort to international cooperation. I am sure the Europeans will not cooperate, based upon the conversations that I've had. They don't have the money, to begin with.

But there is a good possibility that either the Canadians or the Japanese might be suitable partners. I am struck by the fact that the Japanese are building one of the world's finest observatories in Hawaii, all at their own expense, without asking for any U.S. cooperation. And this will contribute to Japan's record of buying up most of the United States and now most of its science facilities.

I expect to see that continue. Funding or assisting in funding the SSC would seem to be a natural extension of that kind of a process.

I thank the Chairman for indulging me in these brief remarks.

The CHAIRMAN. I thank the gentleman from California, and recognize the distinguished young lady from Rhode Island.

OPENING STATEMENT OF HON. CLAUDINE SCHNEIDER, RANKING REPUBLICAN MEMBER, SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

Miss SCHNEIDER. Thank you. I will be very brief, and I would appreciate it, Mr. Chairman, if I could have my entire statement included in the record.

The CHAIRMAN. No objection. So ordered.

Miss SCHNEIDER. Rather than be redundant, I would just like to interject one point to follow up on my colleague from California where he says that the question we will pose to, at least, Mr. Ritter—but I would like to suggest we will pose it to other witnesses here today—is to address the question that I believe this Committee is facing. That is that we have $169.2 billion to deal with insofar as our domestic programs are concerned. Granted that is limited, especially when you recognize that the entire Federal research budget is using 73 percent of that budget for military purposes.

So, I think that, given the fact that we do have a limited pot to deal with, we have to determine what some of those priorities are. I think last week there is an example to us given in the Budget Committee, whereby they were fighting over every proposal in the President's request. And I think we are constantly seeing this kind of competition come to the forefront.

I just had a reporter leave my office talking about some of the changes that are taking place at the National Cancer Institute for research there. So, I think scientists are competing, and I would like to hear from the witnesses some of their specific concerns about that, also.

Thank you, Mr. Chairman.

The CHAIRMAN. We thank the young lady. The Chair recognizes the distinguished gentleman from Illinois, Mr. Fawell.

OPENING STATEMENT OF HON. HARRIS W. FAWELL, THE REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Mr. FAWELL. Thank you, Mr. Chairman. I shall be brief, also. I do commend you for the holding of this hearing, which will cover many important issues relating to the Superconducting Super Collider. We all have our questions and our concerns regarding the site selection process, the progress of the research program, and other issues.

The one issue which I would like to briefly address is technology transfer. I think many of our colleagues have questioned whether the SSC is too arcane or too remote for "practical" benefit. While high energy physics is undoubtedly a very basic science, I believe we need to be reminded that the technology that is needed to support research is at least as important as the research itself. In other words, learning how to construct the machine itself, the SSC will contribute to our engineering expertise in superconducting technologies, computer controls, vacuum technologies, and many other fields. The SSC will not be just a concrete tunnel. It will be a high-technology, high precision instrument for science and education.

I would like to also share with my colleagues a letter I received from a Dr. Steven Errede of the University of Illinois. Dr. Errede clearly and succinctly describes the spinoffs from past accelerator technology, nuclear magnetic resonance imaging, PET scans, proton beam therapy for cancer treatment, and others. And I believe that you will find this letter to be of interest.

[The information referred to follows:]

University of Illinois
at Urbana-Champaign

Department of Physics
Loomis Laboratory of Physics
1110 West Green Street
Urbana
Illinois 61801

March 15, 1988

The Honorable Harris Falwell
United States House of Representatives
Washington, D.C. 20515-1313

Dear Congressman Falwell,

I am writing to you to urge your support for the President's FY '89 budget request for basic science in general and the SSC (Superconducting Super Collider) project in particular. Federal support of basic science, much of which cannot be funded by the private sector, is of critical importance for the national economy, and is also a sound investment in future of this country. The SSC project of the Department of Energy is among the basic science efforts designated for substantial appropriation of $363M in FY '89, $283M of which is intended to be used to begin construction of the SSC.

The SSC is crucial for the continued vitality of high energy physics in this country; it is a field of basic research actively pursued by myself and my colleaques, your constituents. We in the U.S. high energy physics community have worked on the design of the SSC for well over six years. It is the logical next step in the international high energy physics research program and is soundly based on small extensions to existing, well-proven superconducting magnet technology developed at the Fermi National Accelerator Laboratory and at other research laboratories here in the U.S.

History has shown that support of basic science pays for itself many times over. Because of the efforts of the few physicists who struggled to understand the basic principles of electricity and magnetism in the last century, and with the great progress in this century by the efforts of many scientists and engineers, we now have many things that we commonly use in our everyday lives, such as computers, radio, television, satellite communications, lasers, etc. all of which help to make our lives better. Electronic technology is used in all areas of scientific research, in hospitals, businesses and in homes. This is only one example of the impact of basic research on our country. The impact on and benefits to society are both short-term and long-term in nature.

The technological spinoffs from high energy physics to society have been many. The superconducting wire developed at Fermilab for use in the TeVatron magnets made possible the development of large superconducting magnets now in routine, large-scale use at NMR (Nuclear Magnetic Resonance) Imaging facilities in hospitals. Similarly, PET (Positron Emission Tomography) Scanning facilities in hospital are also an outgrowth of high energy physics. The Loma Linda Medical Center in California is currently building a proton therapy facility (based on the neutron therapy facility currently in operation at Fermilab) which was designed by accelerator physicists at Fermilab. The high energy physics community has been a collaborative partner to the computer industry since the early 1960s in developing the fastest, most powerful computers in the world. The Fermilab's ACP (Advanced Computer Project) is an explicit example of this kind of effort. Various kinds of particle accelerator technologies and particle physics technologies are now routinely being used as a means for doing basic research and applied research in many other fields of science, such as biology, chemistry, medicine, geology as well as physics. Recent advances in our understanding of muon-catalyzed fusion may one day provide us all with a virtually unlimited source of safe, clean energy! Here at the University of Illinois, we are engaged in basic research to develop a fundamentally new type of particle detector for use in experiments at the SSC, using semiconducting polymers (conducting plastics). If successful, because such devices are expected to be very inexpensive, it would then be possible to envision their wide-spread use in people's homes to detect unsafe levels of radon gas.

The list of technological spin-offs originating from basic research high energy physics alone is practically endless and is also of great benefit to the citizens of this country! Basic research provides training and education for all types of people: high school, undergraduate and graduate students, post-doctoral research assistants, technicians, engineers, etc. The physics questions we seek answers to from experiments to be done at the SSC will help us to better understand the nature of our universe, and our role in it.

The high energy physics community needs a clear signal from our own government in order to obtain foreign support for the SSC project. From initial contacts made with several countries in Europe, as well as Japan, India and other countries, it appears that it will be possible to obtain financial commitments from these countries for up to 40% of the total $5.3B cost of the SSC, thus considerably reducing the burden of the SSC for the American tax-payer. However, no commitments will be forthcoming from these countries until the U.S. makes its own commitment to the SSC project first.

If the SSC project is long delayed, we risk losing the SSC altogether. This (in my opinion) would be a severe blow to our national pride, and would have serious impact for the future well-being of this country. The international field of high energy physics is extremely competitive. At present, the Europeans are hesitating on their plans to build the LHC (Large Hadron Collider). The Russians also have plans for building a new accelerator which will be highly competitive with the U.S.'s own SSC. Both groups are watching what will happen here in the U.S. If we do not go forward with the SSC the Europeans will certainly build the LHC. The foreign countries now willing to help fund the SSC may instead choose to fund the LHC in order to maintain progress in this field.

We therefore look to you for leadership and your support in approval of the SSC project in FY '89 during the budgetary process in Congress in the upcoming months.

Sincerely,

Steven Errede

Steven M. Errede
Asst. Prof. Physics

Mr. **Fawell**. Thank you, Mr. Chairman. I look forward to this discussion that will ensue.

The **Chairman**. I thank the gentleman from Illinois. The chair recognizes the distinguished gentleman from Texas, Mr. Smith.

OPENING STATEMENT OF HON. LAMAR SMITH, THE REPRESENTATIVE IN CONGRESS FROM THE 21st DISTRICT OF THE STATE OF TEXAS

Mr. **Smith of Texas**. Mr. Chairman, in his fiscal year 1989 budget proposal, President Reagan recommended that Congress authorize $338 million for initial development and construction of the Superconducting Super Collider. On March 17, the House Budget Committee reported a fiscal year 1989 budget resolution that would cut the President's proposed science budget by $1.45 billion.

The Committee suggested that only $100 million be allocated to the SSC project, less than a third of what the President requested. I am very much concerned that, if adequate funding for the SSC is not provided in the fiscal year 1989 budget, the resulting loss of momentum will make it extremely difficult to ensure adequate political support in future years.

I hope the Committee will closely examine the ramifications of such a severe cut in the SSC budget proposal. Hopefully, the record established here will be useful in convincing our colleagues outside the Committee that this project, which is so essential to United States leadership in the scientific field, must be given the strong financial support necessary to get construction underway during the coming fiscal year.

Thank you, Mr. Chairman.

The **Chairman**. I thank the gentleman.

Are there any other opening comments?

PANEL 1: MEMBERS OF CONGRESS

The **Chairman** The Chair therefore then recognizes two of our distinguished members, presently a member of our committee, the distinguished Mr. Ritter from Pennsylvania, and accompanying him would be Mr. Joe Barton from Texas, a former Member of this Committee.

The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Ritter.

STATEMENT OF HON. DON RITTER, RANKING REPUBLICAN MEMBER, SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT

Mr. **Ritter**. Thank you, Mr. Chairman. And I want to commend you and the Committee for holding these important hearings.

The debate over the SSC is really more a debate over priorities, and I am, for one, glad to see that this debate over science priorities in America is taking place.

The $5 billion Superconductor Super Collider is a project we just can't afford. It's also potentially damaging to other basic science in America.

Now that all but seven States have been eliminated from the SSC site selection process, the remaining States should help put an end to the process. It's time to face up to the facts about the SSC.

The SSC, with its multi-billion dollar price tag, endangers funding for science research in other fields, and potentially even for non-SSC particle physics itself.

By authorizing funding for the SSC, Congress would commit a significant portion of the science budget, squeezing out billions of dollars from other important programs over the next decade and beyond.

Congress could not fund the SSC and other multi-billion commitments, such as the Space Station, and even the revitalization of the Shuttle Program, much less healthy growth, a doubling, it is proposed, in the National Science Foundation budget.

There's just a finite amount of money for science programs. Science and technology fared relatively well in recent budget negotiations, with the House Budget Committee increased funding for Budget Function 250 by $1.65 billion. But the Budget Committee recognized that the SSC could not be funded at the expense of other programs.

The Concurrent Budget Resolution calls for $100 million in R&D funding, a sharp decrease from the original $363 million request.

Now that's barely the tip of the iceberg, when compared with the approximately $500 million per year required over the next decade to build the SSC, and then nearly $300 million a year onwards in operating expenses.

We could find ourselves in an annual authorization and appropriations showdown much like our experience with the ill-fated Clinch River Breeder Reactor project. Even $100 million in funding for the SSC would hamper important initiatives in semiconductors, superconductivity, biotechnology, ceramics, material sciences, photonics, robotics, manufacturing sciences, and the list goes on and on.

These are the areas which determine our fate as a world leader, the quality of our jobs, and the quality of our lives.

Also the cost of big science has increased tenfold over the past 15 years. Princeton Nobel Laureaute Philip Anderson says science in the U.S. is dying of giantism. Major new science projects are so vast that no single nation can fund them alone. If the SSC is to be built and operated, we need subtantial agreements for international cost-sharing, or perhaps yet let some of those competing states make substantial commitments.

The Department of Energy admitted last week it still has no formal commitment from Japan or Western Europe. Japan and Western Europe will continue to spend on science to enhance their competitiveness in the global economy, and they will take the free ride on our SSC. If we are to compete in this global economy, we need to set priorities for scientific research. We are in a race for world economic leadership based on science and technology, and the SSC is the wrong choice as a priority project for reaching that goal.

Mr. Chairman, to test that premise, I wrote in December to the president of the Industrial Research Institute, IRI, Dr. S. Allen Heininger of the Monsanto Company. IRI represents over 250 of the main private sector R&D leaders in America. The response from IRI members to the SSC is sobering. Many of them have written to me personally to express their grave concern for the future of American science if the SSC is built.

Dr. Kumar Patel, executive director of research for AT&T Bell Labs, writes, "Our nation's international status in manufacturing is slipping." He concludes that we should put the SSC "near the bottom of our priorities."

Mr. Chairman, I would like to share with you a few more of the responses which I received from IRI members. Dr. J. J. Wise, vice president for research of the Mobil Research and Development Corporation, wrote that, "It is highly speculative whether the SSC will ultimately provide new information and understanding of particle physics that can be translated into benefits to industry and the nation as a whole."

Mr. F. Thomas Krotine, senior vice president of corporate research and development for the Sherwin Williams Company, wrote that "I am most concerned about the potential for draining more scientists and engineers from the talent pool in a period when university output is diminishing."

Dr. Walter L. Robb, senior vice president for corporate R&D of the General Electric Company, wrote that, "Investing more heavily in this area, when there are so many other high priority items that need to be funded simply doesn't make good sense."

I would like, Mr. Chairman, at this point to insert for the record a summary of all the IRI responses.

[Information to be furnished follows:]

FOR RELEASE: Immediate
CONTACT: Joel Eisen, (202) 225-8483

INDUSTRIAL RESEARCH INSTITUTE MEMBERS SPEAK OUT AGAINST THE SUPER COLLIDER

February 17, 1988

In a speech on the House floor, Representative Don Ritter (R-PA) announced today that leading members of the industrial research and development community have spoken out against the Superconducting Super Collider (SSC), the $5 billion, 52-mile racetrack for colliding subatomic particles. Ritter wrote to Dr. S. Allen Heininger, Corporate Vice President of Resources Planning for the Monsanto Company and President of the Industrial Research Institute (IRI), a group which represents some 250 leading technology-based firms involved in research and development. Ritter presented his views on the SSC, asking that those views be shared with the IRI membership. Dr. Heininger then solicited the views of the private sector R&D chiefs on the desirability of proceeding with the massive project, and asked that those views be sent directly to Ritter.

"The response," said Ritter, "was sobering." Of the 17 responses which Ritter has received thus far, all but two have spoken out at length against the SSC; one of those two is a regional neighbor to a prime SSC site. The IRI members believe that the SSC is potentially fatal to American science, that it cannot be justified from a financial standpoint, and that it will have an adverse impact on American science and competitiveness. Ritter pointed out that opinions may turn against the SSC as a result of the narrowing of the eligible sites to seven from over thirty, and because Americans are realizing that we can't afford the SSC or its damaging blow to American science. "Now," he added, "the leaders in the private sector R&D community have shown that they, too, are deeply concerned for America's science and technology future if the SSC is built."

"Basically," added Ritter, "the industrial R&D community was not consulted. In the face of global economic challenges, this is science policy for disaster."

Ritter said that he is continuing to receive responses on a daily basis from IRI members. He listed the following synopsis of the initial responses:

Name of Respondent	Remarks
Dr. C. K. N. Patel Executive Director, Research, Materials Science, Engineering, and Academic Affairs Division AT&T Bell Laboratories	"The argument that the technologies developed in the process of building the SSC will contribute to the overall strength of the U.S. ... is patently unjustified."

"SSC appears to be a distortion of the nation's priorities."

Mr. Richard I. Mateles
Vice President-Research
Stauffer Chemical Company

"High energy particle physics is certainly an intellectually stimulating field, but it is not more important than superconductivity, robotics, photonics, super-computing, or numerous other areas."

"...other areas are going to see a decrease as the funds are moved from other programs into the SSC."

Mr. F. Thomas Krotine
Senior Vice President
Corporate Research and Development
The Sherwin-Williams Company

"...the potential for flow-through of science from SSC is not apparent."

"I believe that the SSC is a poor choice compared to other U.S. priorities."

"I am most concerned about the potential for draining more scientists and engineers from the talent pool in a period when university output is diminishing."

Dr. J.J. Wise
Vice President-Research
Mobil Research and Development Corporation

"It is highly speculative whether the SSC will ultimately provide new information and understanding of particle physics that can be translated into benefits to industry and the nation as a whole."

"Considering the trade-offs that would have to be made to pursue the scientific possibilities of the SSC, I do not feel that the construction of the SSC can be justified at this time."

Mr. Patrick J. Carroll
Director, Corporate R&D
Machinery & Defense Operations
FMC Corporation

"It is my opinion...that the SSC should be postponed by several years and short term emphasis be placed on programs that address the productivity of the U.S. manufacturing base."

Dr. John N. Dempsey
Vice President -

"The value of SSC from a practical standpoint in terms

Science and Technology Bemis Company, Inc.	of benefits to the average man in the street, industrial competitiveness, [is] very far in the future - that's a given." "I feel that SSC should be delayed until we sort out the priority programs that bear on the very survival of our country. Until we fund those programs adequately, there is no room for SSC."
Mr. I. G. Snyder, Jr. Vice President, Dow U.S.A. Director of Applied R&D Dow Chemical Company	"It seems our nation needs to reassess our mechanisms for priority setting in the total R&D budget process." "Your position on the SSC is very appropriate."
Dr. Chester D. Szymanski Corporate Vice President Research and Development National Starch & Chemical Corporation	"There are clearly other research areas in need of additional funding where the practical and economic gains will be greater and can be measured in lives saved or in quality of life improvements or simply jobs created for our people, rather than scientific advancement in a narrow area and the possibility of Nobel Laureates." "The area of particle physics research is requiring increasingly greater expenditures for more difficult explorations with diminishing returns."
Mr. D. B. Rogers General Director Research and Development Dupont Electronics	"The price tag [for SSC] is unconscionably high." "It is difficult for me to understand how the SSC could rank on a national priority list that includes biomedical research, superconductivity, photonics, high density semiconductor integration and interconnection, structural composites, fossil fuel recovery, alternate sources of energy factory automation, etc."

Mr. Walter L. Robb Senior Vice President Corporate Research and Development General Electric Company	"Investing more heavily in this area, when there are so many other high priority items that need to be funded, simply does not make good sense."
Mr. F. B. Sprow Vice-President, Corporate Research Exxon Research and Engineering Company	"With a 'zero sum' budget, this [the SSC] hurts much of the effort that I believe is most important to progress on the competitiveness issue in this country."
Dr. S. Allen Heininger Corporate Vice President, Resources Planning Monsanto Company	"It is my conclusion that undertaking a new initiative of the magnitude of the SSC ... would not serve the national interest at this time."
Dr. Grady W. Harris Vice President, Research & Development Hollister Company (Libertyville, IL)	"We should not build the S.S.C. at this time."
	"I feel that the proposed S.S.C. should be postponed, and that Higher priority research areas such as AIDS, superconductivity, and supercomputing should receive the funding instead."

Mr. Ritter. Considering them, it seems, Mr. Chairman and my colleagues, that the industrial community, excepting those firms which are potential contractors for the SSC, was not consulted.

Mr. Chairman, America is still tops in basic research, particularly particle physics, but there are troubled spots elsewhere. The challenge to America today is to make scientific discoveries and speed up their commercialization. That means making things that people want to buy, making them faster, of higher quality, and less expensively, and have science and technology play its appropriate role in that process.

The SSC, though, will only produce more of the most basic science and will encourage our best minds to concentrate on particle physics at the expense of other worthy endeavors.

SSC proponents argue that it will produce technological spinoffs to help make America more competitive. And I listened to the comments of my colleague from Illinois, Mr. Fawell. It's a question of what the priorities are and how do you get there? Do you look for indirect benefits, or perhaps look for a little more direct benefits?

A project devoted to investigating subatomic particles is not the appropriate way to make America more competitive, not at this stage. The SSC does have basic scientific merit, but America can become more competitive by investing in areas of greater growth and promise.

In a very real sense, Mr. Chairman, going forward with funding of the SSC at this time would be anticompetitive to America.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Ritter follows:]

TESTIMONY OF
THE HON. DON RITTER (R-PA)
AT THE
HEARING OF THE SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE ON THE SUPERCONDUCTING SUPER COLLIDER (SSC)
MARCH 22, 1988

THE $5 BILLION SUPERCONDUCTING SUPER COLLIDER (SSC) IS A PROJECT WE CAN'T AFFORD. IT'S ALSO POTENTIALLY DAMAGING TO OTHER BASIC SCIENCE IN AMERICA.

NOW THAT ALL BUT SEVEN STATES HAVE BEEN ELIMINATED FROM THE SSC SITE SELECTION PROCESS, THE REMAINING STATES SHOULD HELP PUT AN END TO THE PROCESS. IT'S TIME TO FACE UP TO THE FACTS ABOUT THE SSC.

THE SSC, WITH ITS MULTI-BILLION DOLLAR PRICE TAG, ENDANGERS FUNDING FOR SCIENTIFIC RESEARCH IN OTHER FIELDS AND POTENTIALLY IN NON-SSC PARTICLE PHYSICS ITSELF. BY AUTHORIZING FUNDING FOR THE SSC, CONGRESS WOULD COMMIT A SIGNIFICANT PORTION OF THE SCIENCE BUDGET, SQUEEZING OUT BILLIONS OF DOLLARS FROM OTHER IMPORTANT PROGRAMS OVER THE NEXT DECADE AND BEYOND. CONGRESS COULD NOT FUND THE SSC AND OTHER MULTI-BILLION DOLLAR COMMITMENTS SUCH AS THE SPACE STATION AND EVEN THE REVITALIZATION OF THE SHUTTLE PROGRAM, MUCH LESS HEALTHY GROWTH IN THE NATIONAL SCIENCE FOUNDATION BUDGET.

THERE'S A FINITE AMOUNT OF MONEY FOR SCIENCE PROGRAMS. SCIENCE AND TECHNOLOGY FARED RELATIVELY WELL IN THE RECENT BUDGET NEGOTIATIONS, WHERE THE HOUSE BUDGET COMMITTEE INCREASED FUNDING FOR BUDGET FUNCTION 250 BY $1.65 BILLION. BUT THE BUDGET COMMITTEE RECOGNIZED THAT THE SSC COULD NOT BE FUNDED AT THE EXPENSE OF OTHER PROGRAMS; THE CONCURRENT BUDGET RESOLUTION CALLS FOR $100 MILLION IN R&D FUNDING, A SHARP DECREASE FROM THE ORIGINAL $363 MILLION REQUEST. THAT'S BARELY THE TIP OF THE ICEBERG WHEN COMPARED WITH THE APPROXIMATELY $500 MILLION PER YEAR REQUIRED OVER THE NEXT DECADE TO BUILD THE SSC. WE COULD FIND OURSELVES IN AN ANNUAL AUTHORIZATION AND APPROPRIATION SHOWDOWN, MUCH LIKE OUR EXPERIENCE WITH THE ILL-FATED CLINCH RIVER BREEDER REACTOR PROJECT.

EVEN $100 MILLION IN FUNDING FOR THE SSC WOULD HAMPER IMPORTANT INITIATIVES IN SEMICONDUCTORS, SUPERCONDUCTIVITY, BIOTECHNOLOGY, CERAMICS, MATERIALS SCIENCES, PHOTONICS, ROBOTICS, AND MANUFACTURING SCIENCES. AND THESE ARE THE AREAS WHICH DETERMINE OUR FATE AS A WORLD LEADER, THE QUALITY OF OUR JOBS, AND THE QUALITY OF OUR LIVES.

ALSO, THE COST OF "BIG SCIENCE" HAS INCREASED TEN-FOLD OVER THE PAST 15 YEARS. PRINCETON NOBEL LAUREATE PHILIP ANDERSON SAYS "SCIENCE IN THE U.S. IS DYING OF GIANTISM." MAJOR NEW SCIENCE PROJECTS ARE SO VAST THAT NO SINGLE NATION

CAN FUND THEM ALONE. IF THE SSC IS TO BE BUILT AND OPERATED, WE NEED SUBSTANTIAL AGREEMENTS FOR INTERNATIONAL COST-SHARING. YET THE DEPARTMENT OF ENERGY ADMITTED LAST WEEK THAT IT STILL HAS NO FORMAL COMMITMENTS FROM JAPAN OR WESTERN EUROPE. JAPAN AND WESTERN EUROPE WILL CONTINUE TO SPEND ON SCIENCE TO ENHANCE THEIR COMPETITIVENESS IN THE GLOBAL ECONOMY, AND THEY'LL TAKE THE FREE RIDE ON OUR SSC.

IF WE'RE TO COMPETE IN THE GLOBAL ECONOMY, WE NEED TO SET PRIORITIES IN SCIENTIFIC RESEARCH. WE'RE IN A RACE FOR WORLD ECONOMIC LEADERSHIP BASED ON SCIENCE AND TECHNOLOGY, AND THE SSC IS THE WRONG CHOICE AS A PRIORITY PROJECT FOR REACHING THAT GOAL. TO TEST THAT PREMISE, I WROTE IN DECEMBER TO THE PRESIDENT OF THE INDUSTRIAL RESEARCH INSTITUTE (IRI), DR. S. ALLEN HEININGER OF THE MONSANTO COMPANY. IRI REPRESENTS OVER 250 OF THE MAIN PRIVATE SECTOR R&D LEADERS OF AMERICA. THE RESPONSE FROM IRI MEMBERS TO THE SSC IS SOBERING. MANY OF THEM HAVE WRITTEN TO ME PERSONALLY TO EXPRESS THEIR GRAVE CONCERN FOR THE FUTURE OF AMERICAN SCIENCE IF THE SSC IS BUILT. DR. KUMAR PATEL, EXECUTIVE DIRECTOR OF RESEARCH FOR AT&T BELL LABORATORIES, WRITES THAT "[O]UR NATION'S INTERNATIONAL STATUS IN MANUFACTURING...IS SLIPPING." HE CONCLUDES THAT WE SHOULD PUT THE SSC "NEAR THE BOTTOM OF OUR PRIORITIES."

MR. CHAIRMAN, I'D LIKE TO SHARE WITH YOU A FEW MORE OF THE RESPONSES WHICH I RECEIVED FROM THE IRI MEMBERS. DR.

J.J. WISE, VICE PRESIDENT FOR RESEARCH OF THE MOBIL RESEARCH AND DEVELOPMENT CORPORATION, WROTE THAT "IT IS HIGHLY SPECULATIVE WHETHER THE SSC WILL ULTIMATELY PROVIDE NEW INFORMATION AND UNDERSTANDING OF PARTICLE PHYSICS THAT CAN BE TRANSLATED INTO BENEFITS TO INDUSTRY AND THE NATION AS A WHOLE." MR. F. THOMAS KROTINE, SENIOR VICE PRESIDENT OF CORPORATE RESEARCH AND DEVELOPMENT FOR THE SHERWIN-WILLIAMS COMPANY, WROTE THAT "I AM MOST CONCERNED ABOUT THE POTENTIAL FOR DRAINING MORE SCIENTISTS AND ENGINEERS FROM THE TALENT POOL IN A PERIOD WHEN UNIVERSITY OUTPUT IS DIMINISHING." DR. WALTER L. ROBB, SENIOR VICE PRESIDENT FOR CORPORATE RESEARCH AND DEVELOPMENT OF THE GENERAL ELECTRIC COMPANY, WROTE THAT "INVESTING MORE HEAVILY IN THIS AREA, WHEN THERE ARE SO MANY OTHER HIGH PRIORITY ITEMS THAT NEED TO BE FUNDED, SIMPLY DOES NOT MAKE GOOD SENSE."

I WOULD LIKE AT THIS POINT TO INSERT, FOR THE RECORD, A SUMMARY OF ALL OF THE IRI RESPONSES. CONSIDERING THEM, MR. CHAIRMAN, IT SEEMS THAT THE INDUSTRIAL COMMUNITY (EXCEPTING THOSE FIRMS WHICH ARE POTENTIAL CONTRACTORS FOR THE SSC) WAS NOT CONSULTED.

MR. CHAIRMAN, AMERICA IS STILL TOPS IN BASIC RESEARCH, PARTICULARLY PARTICLE PHYSICS, BUT THERE ARE TROUBLE SPOTS ELSEWHERE. THE CHALLENGE TO AMERICA TODAY IS TO MAKE SCIENTIFIC DISCOVERIES AND THEN SPEED UP OUR COMMERCIALIZATION OF THEM. THAT MEANS MAKING THINGS THAT

PEOPLE WANT TO BUY...MAKING THEM FASTER, OF HIGHER QUALITY AND LESS EXPENSIVELY. THE SSC, THOUGH, WILL ONLY PRODUCE MORE OF THE MOST BASIC SCIENCE, AND WILL ENCOURAGE OUR BEST MINDS TO CONCENTRATE ON PARTICLE PHYSICS AT THE EXPENSE OF OTHER WORTHY ENDEAVORS.

SSC'S PROPONENTS ARGUE THAT IT WILL PRODUCE TECHNOLOGICAL SPINOFFS TO HELP MAKE AMERICA MORE COMPETITIVE. BUT A PROJECT DEVOTED TO INVESTIGATING SUB-ATOMIC PARTICLES IS NOT THE APPROPRIATE WAY TO MAKE AMERICA MORE COMPETITIVE. THE SSC DOES HAVE BASIC SCIENTIFIC MERIT, BUT AMERICA CAN BECOME MORE COMPETITIVE BY INVESTING IN AREAS OF GREATER GROWTH AND PROMISE. IN A VERY REAL SENSE, GOING FORWARD WITH FUNDING FOR THE SSC AT THIS TIME WOULD BE ANTI-COMPETITIVE FOR AMERICA.

The CHAIRMAN. I thank the gentleman from Pennsylvania.

The Chair recognizes the distinguished gentleman from Texas, Mr. Barton.

STATEMENT OF HON. JOE BARTON, THE REPRESENTATIVE IN CONGRESS FROM THE 6TH DISTRICT OF THE STATE OF TEXAS

Mr. BARTON. Thank you, Mr. Chairman.

It's good to testify before my old Committee and see all the friendly faces here. I am glad to be back, if only for a short time.

My testimony is going to take a little different tack than my good friend from Pennsylvania, Mr. Ritter. To quote Paul Harvey, we are going to talk about, or I am going to talk about the other side of the story, so to speak, the rest of the story.

Thank you, Don.

The Super Collider is one of the most important research projects ever undertaken by the United States. It will be the world's most powerful proton-proton collider, producing particle collisions with total energies 20 times the highest energy available in the world today.

I support authorization of the project immediately, and I urge you and the committee to authorize the SSC this year.

Understanding the nature of the world around us will provide research advances of literally cosmic proportions. As President Reagan stated in his January message to the Congress, the SSC is "essential to continued United States leadership in high energy physics and America's scientific and technological competitiveness."

With support for full funding of the Super Collider, the President has given his commitment for the United States to remain in the forefront of basic science technology and research for many years to come.

The President's decision, with the Congress' concurrence, will allow us to build on the scientific and technological advances of the past. The development of the SSC will usher in a new era in science and technology, much as the discovery of the electron did 100 years ago.

Since the emergence of high energy physics as a separate field of research, the United States has led the world. However, I am concerned about losing our preeminence in high energy physics, first to Europe with the Center for European Research in Nuclear at CERN, which Congressman Brown spoke of, and perhaps even to the Soviet Union, with their planned collider called the UNK.

By building the SSC, the United States will maintain its leading positions.

Some opponents of the SSC have claimed it will adversely affect other research and development projects. Just the reverse is true. Areas such as superconductivity, photonetics, robotics and supercomputing will receive increased emphasis because of the SSC. The SSC is the bellwether project for investment in areas of basic research in the hard science area.

The President has advocated doubling the National Science Foundation budget to approximately $3.2 billion over the next five years. This marks a renewed commitment to basic knowledge and basic science, or small science. At this level, the National Science Foundation budget will be three times that for the Superconductor Super Collider project.

Last week the House Budget Committee increased the budget authority for basic science, which includes the SSC funding, by $1.65 billion. It is my understanding that the fiscal year 1989 budget report language will support a minimum of $100 million for the SSC project.

This amount is less than the proposed funding of the SSC of $363 million for construction and research which were included in the President's budget.

I think that the research funding is necessary to finalize the designs for the superconducting dipole magnets and other technical systems.

The construction funding is also necessary to begin such activities as the detailed design of the technical systems and conventional facilities, to begin procurement of the long-lead-time items for the power stations and utilities, and the injector and collider components and their long-lead items.

I strongly urge this Committee to authorize not only research, but some of the early phase construction items also. A substantial portion of the SSC funding can come from non-Federal sources. Inclusion of construction funds and a demonstrable commitment of the United States to the project will encourage international cost-sharing and foreign contributions to flow to the SSC.

Congressman Hall alluded to this in his opening statement.

Private sector money will also be encouraged. I'll give you an example. In my state of Texas, with a high voter participation last November, the people of Texas authorized the State to issue $500 million in general obligation funds to help pay for the SSC's construction, should it be located in Texas.

Texans voted for the bonds because they are dedicated to United States scientific excellence, and believe that scientific excellence is necessary to continue economic excellence.

Both houses of the State legislature and the Governor of Texas have voiced their commitment, with an additional $500 million in funding, which makes the Texas total package $1 billion.

Other States have also exhibited a commitment to cost-sharing for the SSC. The fact that the House Budget Committee last week agreed to support an increase for the SSC funding echoes the understood universal benefit. Even in a time when our Federal deficit mandates cutbacks, the budget function including the SSC was given a large funding increase. I view this as a recognition of the fact that even in times of budgetary restraint, funding programs vital to the future growth of our country are essential.

To summarize, Mr. Chairman, this Committee has already made a commitment to the SSC by including in the authorization bill last year authorization for the project. I would encourage you to continue this commitment, and authorize this project this year.

I would also like to submit for the record a statement from a member of the IRI that Congressman Ritter was referring to.

[Information to be furnished follows:]

W. B. Offutt
Vice President-
Technical Management

Eaton Corporation
Eaton Center
Cleveland, Ohio 44114
(216) 523-4626

January 8, 1988

The Honorable Don Ritter
Member, House of Representatives
2447 Rayburn Office Building
Washington, D.C. 20515

Dear Mr. Ritter:

Dr. Heininger, President of the Industrial Research Institute, has forwarded a copy of your recent letter to me, with the suggestion that I write directly to you giving my opinions on the SSC.

I, too, have contemplated the very great cost of the SSC project and wondered whether it should be funded, especially in the light of other pressing needs in the U.S.A.

Unlike your own feelings, however, I conclude that we should proceed with this project, exactly for some of the reasons you use to question it.

A good guide to what one should do is to decide what one does best, and then do it as earnestly as possible.

You are right, the U.S.A. does enjoy a leading position in high energy physics, and the SSC will help to maintain that position, rather than allowing it to erode as other earlier leading positions were allowed to erode because we were not willing to pay the price of dedication to maintaining excellence.

You are right, this project will inevitably drain funds from other areas...you mention superconductivity, photonics, robotics and supercomputing. But, Mr. Ritter, those other fields are of nearer term commercial and industrial interest, and where they contribute to America's industrial prowess, we in industry will pursue that research in our own self interest...and with better ordered priorities, I might add, than the Federal government. Thus, these other activities have other sources of support, but for the SCC, THERE IS NO OTHER SOURCE OF SUPPORT than the Federal government.

If there is any justification for big government, it is to permit the country to do these projects that are simply too big to do any other way. I'm very proud of the fact that my country put a man on the moon. There was no other way for us to do it than by the Federal government. I'd like to continue to be proud of my country's pre-eminent role in theoretical physics, in the search for what may be man's ultimate understanding of matter, energy, time and the origin of the universe.

You speak of jobs creation, and say, "Perhaps many more jobs will be lost than gained." It seems to me that monies expended go for nothing other than ultimately paying wages and salaries. It is neither buried in the ground nor burned. Money is a surrogate for people's hours. What we are considering is what people's hours should be dedicated to. Monies spent on the SSC will pay for people's hours in the U.S.A. As someone observed a couple of decades ago, every dime used to put a man on the moon was spent here on earth...and every dime for the SSC will be spent on earth, with more of them spent for employment in the U.S.A. than is the case for many other things on which we spend money.

We are entering a period of reduced military R&D spending. I'd like to see our advanced technology capability maintained without dedicating it to more military projects. Just as the NASA program helped do this in the 1960's, I'd like to see the SSC project help do this in the next half decade.

You ask, "Where was the outcry when we lost our competitiveness in automobiles, consumer electronics and machine tools?" The outcry has been loud and clear where I have been spending my career, and the ground we are retaking is being gained by the efforts of the industries involved, not by government spending. Government can make a contribution by keeping the global playing field level, not by spending money where the industrial competitors can do it better themselves. As for the SSC, there is no one other than the government that can support the project.

You ask, "How does the SSC fit into our nation's Science and Technology policy?" It fits in by being the step to maintain our position of excellence in a field where we are already excellent. It is obvious that no country can be leading-edge excellent in everything. The SSC supports a strong area. If instead we apply the monies to a hundred other areas, after it is spent none of us will be able to point to any identifiable gain.

You state, "Industries which are counting on attracting increasing numbers of graduates in electrical engineering, optics, chemistry and materials will have to revise their expectations downward." To the contrary, I believe that industries that make use of the best qualified staffs will have new and exciting contract opportunities with which to attract the best young people to technical fields.

Exciting, dramatic projects attract people to technical fields...for a typical career span of 40 years. For every year the SSC is a major design/construction project, the attracted people will have five or ten times that much productive time in their careers. The SSC project will likely produce a net GAIN over the next few decades in our technical skill base, not a decrease.

The U.S.A. spends about $125 billion on R&D each year. A $4 billion SSC project, spread over five or more years, of which only part will be spent for actual R&D after allowance is made for excavation and construction work, will hardly have a limiting impact on our engineering manpower supply, even during the peak years. After all, the NASA budget is far below its peak level, and NASA spent a greater proportion of its budget on technology per se than the SSC project is likely to average.

You ask where the money is coming from. I left this question to last, because I feel poorly equipped to answer it . It is, however, obvious that the budget process must be made to serve priority national needs. I consider the SSC to be such a need. (The first $8 million required to fund it can be found by reversing the incredible Congressional approval of Senator Inouye's bill for support of parochial school education in France. The budget is still heavy with special interest items of that kind. You know better than I where and how to find them.)

Sincerely,

Warren Offutt

WBO:la

Mr. BARTON. First of all, I'd like to point out that it's obvious that the IRI, which is a commercial research institute, and basically tries to focus its efforts on near- term research that has commercial application in the marketplace, it's no surprise that they're going to be opposed to the SSC project in general terms.

However, their opposition is not universal within that organization. I have here a letter from a Mr. W. B. Offutt, vice president of technical management of the Eaton Corporation, a member of that institute, where he goes on record, at least for himself—I don't know if for his company—stating his support for the SSC project.

I would submit this for the record, and submit my total testimony, which I summarized.

The CHAIRMAN. No objection. So ordered. The full testimony and your other submission will be included in the record.

Does that complete your statement, Mr. Barton?

Mr. BARTON. Yes, sir.

[The prepared statement of Mr. Barton follows:]

TESTIMONY

OF

CONGRESSMAN JOE BARTON
TEXAS, SIXTH DISTRICT

HOUSE SCIENCE, SPACE & TECHNOLOGY COMMITTEE
HEARING ON THE
SUPERCONDUCTING SUPER COLLIDER
SITE SELECTION AND FUNDING REQUIREMENTS

MARCH 22, 1988
2318 RAYBURN

Mr. Chairman, I would like to thank you and the Committee for giving me the opportunity to testify on behalf of the Superconducting Super Collider (SSC). The Super Collider is one of the most important research projects ever undertaken by the United States. It will be the world's most powerful proton-proton collider, producing particle collisions with total energies approaching 40 trillion electron volts, an energy twenty times the highest energies available in the world today. I support authorization of the project immediately, and I urge you and the Committee to authorize the SSC this year.

Understanding the nature of the world around us will provide research advances of literally cosmic proportions. As President Reagan stated in his January message to Congress, the SSC is "essential to continued United States leadership in high-energy physics and America's scientific and technological competitiveness."

With support for full funding of the Super Collider, the President has given his commitment for the United States to remain in the forefront of basic science technology for many years to come. The President's decision--with Congress' concurrence--will allow us to build on the scientific and technological advances of the past.

The development of the SSC will usher in a new era in science and technology, much as the discovery of the electron did 100 years ago. The Super Collider will provide technical innovations, educational discoveries, new medical treatments and commercial spinoffs so profound that the applications and benefits derived will be unimaginable. Today, fully one third of the production making up our gross national product is based on the knowledge of the atom, and an investment in the SSC should increase this percentage in the future.

Since the emergence of high energy physics as a separate field of research, the United States has led the world. However, I am concerned about losing our preeminence in high energy physics, first to Europe with the Center for European Research-Nuclear (CERN) and perhaps to the Soviet Union with their planned collider called the "UNK." By building the SSC, the United States will maintain its leading position.

With an initial construction cost of $4-6 billioan and an annual operating budget in excess of $270 million, the SSC will obviously be a major economic boom for the United States. It is estimated that the SSC will create 4,500 construction related jobs before operation and 2,500 direct, permanent jobs when the project is in operation. Almost 15,000 jobs are expected to be indirectly created.

Some opponents of the SSC have claimed it will adversely affect other research and development projects. Just the reverse is true. Areas such as superconductivity, photonics, robotics and supercomputing will receive increased emphasis because of the SSC. The SSC is the bellweather project for investment in areas of basic research in the "hard" science area.

The President has advocated doubling the National Science Foundation budget to about $3.2 billion over the next five years. This marks a renewed commitment to basic knowledge. At this level, the NSF (or small science budget) will be three times that for the SSC.

Since SSC funding is spread out over many years, the total funding outlay in any given year is relatively modest. This is further enhanced by the fact that many scientists pursuing successful research careers began their studies pursuing particle physics research.

Last week, the House Budget Committee increased the budget authority for Basic Energy Science which includes SSC funding by $1.65 billion. The FY 1989 budget report language will support a minimum of $100 million increase for the SSC project. This amount is less than the proposed funding for the SSC of $363 million for construction and research included in the President's budget. The research funding is necessary to finalize designs for the superconducting dipole magnets and other technical systems. The construction funding would cover such activities as: detailed design of technical systems and conventional facilities; long-lead items for power stations and utilities; and the injector and collider components' long-lead items. I strongly urge this committee to authorize not only research but some of the early phase construction items also.

A substantial portion of the SSC funding can come from non-Federal sources. Inclusion of construction funds and the demonstrable commitment of the United States to the project will encourage international cost-sharing and foreign contributions to flow to the SSC. Private sector money will also be encouraged.

In my state of Texas, with high voter turn-out, the people authorized the state to issue $500 million in general obligation bonds to help pay for the SSC's construction should it be located in Texas. Texans voted for the bonds because they are dedicated to the United States' scientific excellence, and believe that scientific excellence is necessary to continue economic excellence. Both houses of the State Legislature and the Governor have voiced their commitment with an additional $500 million in funding which makes the total Texas funding package equal $1 billion. Other states have also exhibited a commitment to cost-sharing for the SSC.

When viewed in the overall Federal budget of $1.05 trillion, the funding for the SSC is modest indeed. Compare the President's $363 million request to Federal funding for Amtrak at $600 million, mass transit at $2.1 billion, and a NASA funding increase of $1.25 billion. Surely basic scientific research is competitive with these long standing requests. The funding request is especially small when we consider that the SSC will result in profound anticipated and unanticipated discoveries affecting each of our lives.

The fact that the House Budget Committee members agree to support an increase for SSC funding echoes the understood universal benefit. Even our federal deficit mandating cut-backs, the budget function including the Super Collider funding was given the largest funding increase. I view this as recognition of the fact that even in times of budgetary restraint, funding programs vital to the future growth of our country are essential.

The SSC will spend money for employment in the United States. Industries and universities will find exciting new contract opportunities and we will increase our technical skill base. The SSC will attract our brightest young people to study science, plus attract the world's leading physicists to live and work in the United States.

From a national perspective, the SSC will have a tremendous positive impact. Under the current funding schedule, the project can be completed in 1996. All that remains is for you and I to make a commitment to our future.

To quote a Nobel Prize winner from the University of Chicago, James W. Cronin: "The spirit of a nation and the pride of its people can only be enhanced when science, including the exploration of our planet, solar system, galaxy, and universe is among its highest priorities."

The SSC should be amongst our highest priorities. I again urge this committee to authorize this essential project this year.

PANEL 1 DISCUSSION

The **Chairman**. For clarity for the record, if the Chair may, our colleague, Mr. Ritter, I understand from some of our reports that purportedly of the 250 people or whatever who were contacted in the—I guess it's the IRI —Industrial Research Institute—that, first of all, one, only 10 percent responded; 24 which voted—I guess it was 16—I beg your pardon, it was 24 people responded, 16 no and four voted yes. Is that true? Only 10 percent responded? Is that correct?

Mr. **Ritter**. That is correct, Mr. Chairman.

The **Chairman**. Okay.

Mr. **Ritter**. If I might just comment on that, what Mr. Heininger has stated in a, I think, comprehensive report on the IRI question in new technology link, Mr. Heininger states that most people get very cautious about doing something like this, the Monsanto executive said, it's so simplistic that most of them were unwilling to participate, because now you're putting your name on the line.

The question comes down to why does the IRI have the right to prioritize science projects. You can just hear the screams that will come out from those whose projects were not highly favored.

The **Chairman**. Well—

Mr. **Ritter**. I might say that some of the respondents who responded for the SSC—

The **Chairman**.—if the gentleman would yield, all I wanted to do was get an answer, and you have answered the question, only 10 percent responded. I think that's what the issue is.

Let me ask one other question.

Did I understand you to say—and believe me, the last thing in the world I would do would be to put any words in any Member's mouth. I just wasn't sure. I made a note, and I'm not sure I'm correct on it—that you were opposed to the Super Collider because we can't afford it? Or did you say you are opposed to the Super Collider per se? If we could afford it, would you be in favor of the supercollider?

Mr. **Ritter**. If we had infinite resources, Mr. Chairman, to devote to science and technology, it would be a good project.

The **Chairman**. But you're just opposed because of your concern on the priority?

Mr. **Ritter**. I think in terms of priority, I think it's low.

The **Chairman**. That's important. All right.

The Chair recognizes the distinguished gentleman from New Mexico.

Mr. **Lujan**. Thank you very much, Mr. Chairman.

The **Chairman**. And congratulations on the award you received today for your fine years of service.

Mr. **Lujan**. It was a eulogy for going home.

[Laughter.]

The **Chairman**. I was trying to beef it up a little bit. The gentleman from New Mexico.

Mr. **Lujan**. Thank you very much, Mr. Chairman. I'm sorry to be late. I have had an opportunity to review the testimony of our two colleagues, and I thank you for reading my statement. I was concerned about how unbiased and how fair the entire selection was, Joe; not anything having to do because Texas was selected and New Mexico was not, even though we clearly had a superior site, but that—

[Laughter.]

Mr. **Barton**. With you up there and me down here, I'm not going to debate that point.

[Laughter.]

Mr. **Lujan**. But nevertheless I still think it is a project that should go on, and regardless of whether I agree that the selection was done in a way that I would have done it, anyway. It still has nothing to do with it.

I have been concerned, you know, all the time about talking about reducing the effort in other science projects because of the Super Collider, and I would hope at least that, you know, that that does not happen and, of course, I will do everything that I can, that that does not happen. As you know, I have been a supporter of the Super Collider all along, and think we should do it, and yet I guess we all are concerned that we don't use up so much money there that that would hamper the other programs.

It doesn't seem to me to be the way that it's going to go. I think science will be funded at a good level this year. We were fortunate that the Administration put in $2.5 billion additional amount, even though the Budget Committee cut us down a billion, more or less. But I think it would be a tragedy not to move ahead with the Super Collider. Somebody's going to build it, and already, you know, we're not in the shape that we should be, as far as technology is concerned.

So I would hope that we move on ahead with it.

I have no questions, Mr. Chairman, and I thank you for the opportunity.

The **Chairman**. I thank the gentleman from New Mexico. Are there any questions for our colleagues here, anybody have any questions?

The gentleman from Illinois, Mr. Fawell.

Mr. **Fawell**. I guess it's not so much a question as an observation. I don't have the scientific background which Congressman Ritter does have, but I read such statements as written by Chris Quig, and I'll just—I'd like to quote it. "The SSC is a bold and innovative project on a grand scale. The rewards to fundamental science and to our nation will be commensurate. What is the price of not building the SSC? It would mean turning our back on the fundamental scientific field in which the U.S. has traditionally held a position of leadership. It would mean becoming watchers instead of doers. It would mean abdicating our responsibilities to the future as a wealthy and enlightened society on which fortune has smiled. This we cannot do."

And then adding to that the separate statement, "At present apparently the Europeans, too, are hesitating on their plans to build the LHC, and the Russians are hesitating, too, also. They have plans apparently for building a new accelerator which will be highly competitive."

And what we are talking about is basic research, which is hard to finitize, and to be able to point to what the results will be. And yet it seems to me that basic research is the foundation for all the competitiveness to which you refer.

I recognize your argument is that it is anticompetitive, and that competitiveness is primary to you, if I understand your arguments, but that, to me, seems pennywise and pound-foolish—that eventually the day must come when we produce more and obviously we ain't seen nothing yet in terms of this being in high noon of high technology, the era in which we're living. To have America back away from basic research seems to me in the long run having us—we're truly going to be anticompetitive.

I don't know what all the reasons are for a lack of competition, but I suspect, as we've discussed several times, that it is perhaps cultural, as much as anything else. Perhaps our industries don't know how to really cooperate and work together, we have been so competitive in our society.

But I'd like to have your reaction to that. It seems to me you are just selling America short, and eventually in the long run, if we continue with that kind of thinking, we are not going to do basic research, and that basic research is the daddy or the granddaddy of the new discoveries that are coming out of our laboratories now.

Mr. RITTER. If I might respond, Mr. Chairman, I think my friend from Illinois makes a very valid point, and I want to support him in that contention, that basic research is crucial to the competitiveness, if you will, of this enterprise.

The question I raise is not so much basic research versus no basic research. I raise the question of SSC versus expanded work in superconductivity, against expanded work in photonics, which is the next generation of devices beyond electronics. I raise the question of SSC versus robotics and manufacturing sciences. I'd like to have a strong basic research presence, but I think we need to consider priorities, and my point comes out to where the SSC fits on priorities.

The bottom line, as I see it in the Congress, there isn't a strong support for SSC outside of those areas which will benefit significantly and that, to me, raises alarms and red flags. It's not like the Space Program, which the American people have joined together to support. It's not like a doubling of the National Science Foundation's budget, which seems to have a real cross-section of support. And by the way, you can't do SSC and double the NSF budget at the same time. The numbers simply don't work out. I guess that's the point I'm trying to make.

The CHAIRMAN. Will the gentleman yield?

Mr. FAWELL. Yes, I'd be more than glad to yield.

The CHAIRMAN. Well, I think it's important to point—I don't think we can let that statement stand alone, because in the first place, somebody must have been interested. There were 43 States that initially participated. Those States, by the way, spent $15 million amongst themselves. Some of those States have been willing to put up a billion and a half plus—not just Texas, there're other States involved—and you make an interesting point in a different direction.

Do we make science policy on the basis of what Members are going to vote on as it affects their respective States, or do we make science policy on the science that's needed for this country? There's a very grave difference between the two.

Mr. **Ritter**. I agree.

The **Chairman**. And maybe this experiment that we're taking may be a very interesting one to get to a vote ultimately on the Floor, based upon the point of view that if we're to invest our resources, should the resources be invested where the people of this country need those opportunities? Or should it be based on the basis of some politicians who can't get their whack at the apple and, therefore, they withdraw their support?

I think whether or not we feel that the Super Collider is something that is not now something we can put $300 million to is one issue. It's by far a different issue if we are going to decide a science policy in this country made up by who acts out what part and who gets what out of the pot, or who gets the gravy. And that's one thing that's got to stop in this country, because that's the wrong approach to take.

Mr. **Ritter**. Mr. Chairman, I think—I couldn't say it any better. I think that's absolutely true.

The **Chairman**. I'm not convinced—if the gentleman will yield—I'm not convinced that the Members of—we share your concern, of course, but I'm not convinced they're ready to turn this down.

Mr. **Ritter**. If you notice, now that 43 States are no longer competing, and only seven States are competing, the rubber is hitting the road.

The **Chairman**. Wonder how we would have won the war if only 23 or 11 States participated? It's a national decision that has to be made, not one of seven States.

The gentleman from Illinois.

Mr. **Barton**. Mr. Chairman, or Congressman, can I comment on that, if possible?

Mr. **Fawell**. Yes.

Mr. **Barton**. I would share Congressman Ritter's concern for setting priorities. The point that I would make is that this Committee and the Congress should not limit the priority-setting to those items within the science budget. It does not say in the budget agreement or in the Constitution of the United States or in the President's budget or in any document that I have read that all priority decisions shall be limited to items within the purview of Function 250 under the Budget Resolution.

If we are going to set priority, let's look at priorities across the board. Let's compare this project and our basic science policy to all the items that we spend money on at the Federal level. I am confident that if we will do that in a faithful fashion, this project will fare very, very well. I think it fares very well, even within the limited priority-setting of the basic science budget, but it certainly fares very well if we look at it in relation to all the programs that we are spending money on.

The **Chairman**. The gentleman from Illinois.

Mr. **Fawell**. Yes. Well, I've had very able assistance here, and I just want to summarize by saying that I'm still not clear, because basic research—I don't know of any corporations or businesses who are going to undertake this. It just simply won't be done. We'll abdicate. We'll say we can't afford it.

If there's a will, there is a way, and obviously we are not all going to get what we want, I think, parochially. But I have the feeling that even superconductivity, which is very big in my District, as you know, probably can survive and blossom, even if there were no Federal funds. There are an awful lot of corporate entities that are very conscious and aware of that area of potential great source of business.

I still don't believe that we are so poor and that we are so mixed up and that we don't have enough people in Congress who will not support what is simply a grand idea. This is the next step, and an exciting one, that should invigorate the educational community, the science community, the Nation, the world. And we are saying, "oh, we can't make up our mind". And we are going to say that we can't get the national research, we just don't have the wherewithal, we just aren't the same any more. That seems to me to be very defeatist. I, for one, know that if this particular plan, for instance, may not come to Illinois, we could suffer. But I think it's good for the Nation, and I'll be for it whether it goes to Illinois or not. And I just believe that that type of basic research, we just can't walk away from.

Thank you.

Mr. RITTER. If I might just respond. I know the gentleman is sincerely committed to the SSC. I would say to the gentleman, though, it is not a question of basic research versus no basic research, once again. There are other areas which seem to have a far higher priority these days, and as I said to the Chairman, if we had infinite resources, or unlimited resources, or we didn't have a budget deficit, or we didn't have a budget crunch in Function 250 and elsewhere in the domestic side of the Federal budget, I could support this as a great idea.

But I think it's a greater idea to put more money in superconductivity. I think it's a greater idea to put more money in photonics. I think it's a greater idea to put more money in biotechnology and robotics and manufacturing sciences, areas that are going begging, because again, to quote Philip Anderson, we've got this preoccupation with big science, and big projects, and splendid ideas, and the little guy in the laboratory is really doing the yeoman service. So many of the advances in superconductivity, the Paul Chu work at Houston, come out of small unknown programs that never hit the paper until the breakthrough is made. And we didn't make gigantic investments.

The CHAIRMAN. All right, the Chair—we've got a Floor—what is it going to be, four votes? We'll go on the second call. There's going to be four suspension votes.

The Chair recognizes the distinguished gentlelady from Rhode Island.

Miss SCHNEIDER. Thank you, Mr. Chairman. I will attempt to be as speedy as possible. I would like to commend my colleague from Pennsylvania for the very clear statement that you have provided us with, which I think can be summarized in suggesting that financing of this project to the tune that we are suggesting would be anticompetitive.

I'd like to ask a very specific brief question, for starters. The Budget Committee last week had decided to include $100 million for the SSC. Do you believe that we would need to spend $100 million if we limited this funding to just R&D?

Mr. RITTER. Probably not that much. But, you know, we're still dealing with a magnet that we don't have a prototype of, so there's research and development going into creating the first magnet for the SSC, which there will be 10,000 of.

Miss SCHNEIDER. Okay.

Mr. RITTER. The second part of the question is, I don't think it's fair to start this ball rolling at $100 million out of $5 billion. We're talking a miniscule percentage, and we can set people in motion and—

Miss SCHNEIDER. Right. Now this is your opinion, but you also received opinions from a number of different industries. Would you just briefly give us the girth of those respondents?

Mr. RITTER. Well, I think the gentlelady might have stepped out when we did go through this.

Miss SCHNEIDER. Sorry about that. Then I'll withdraw that question.

Mr. RITTER. The Chairman made a comment about four promoting the SSC, and to the extent we could understand those four, three were basically either contractors or contractor States, and the gentleman quotes the Eaton Corporation—I didn't know which one that was—and several came later, I might add.

But the overwhelming cross section of the industry is opposed.

Miss SCHNEIDER. Well, despite the variety of opinion on this Committee, I think that we are unanimous in one belief, and that is that there needs to be some priority- setting, insofar as how we are financing our science research disciplines.

Now it seems to me that we have individuals from the private sector, from academia and from Government, who participate in such advisory boards as the Energy Research Advisory Board, or the National Science Board, and a whole broad spectrum of other advisory groups.

What role do you feel that they should play in assisting Congress to determine what these priorities should be?

Mr. RITTER. I think the gentlelady makes an excellent point. I think the Chairman has begun to initiate a wide-ranging discussion of priorities for American science, and if we did nothing else as a committee over the next 10 months, begin a process to set these priorities, using the organizations you mentioned, I think that would have a very salutory effect and, frankly, I have a feeling that some of these very large-scale projects might end up a little bit lower on the priority list.

Miss SCHNEIDER. I think that if I could lend my recommendation to the Chairman and to the Committee, I know that the scientific community is up in arms about the meager number of dollars that are available for a variety of different disciplines, and if we are to set priorities rather than have them focus on the minute programs, they perhaps should focus on broader categories, such as health care, and under health care, then we look at AIDS research and Alzheimer's Disease research, or research funding for various nuclear resident systems, and a whole broad spectrum under health, et cetera.

But it seems to me that this would aid us in setting our priorities.

Mr. BARTON. Could I make a comment on your first question, Congresswoman?

Miss SCHNEIDER. Yes. Certainly.

Mr. BARTON. The question about research funding versus construction funding, the project has been in the discussion stage since the late 1970's. The Department of Energy has been spending money on researching the project since at least 1984. They are ready now to begin to construct the project. It would begin operation in 1996.

There is a limited amount of money that can be spent on a purely research project. Congressman Ritter referred to the fact that there is not an existing magnet. That's a true statement, for the simple fact that they've been in a testing program for the last year, year and a half.

Now Dr. Tigner is going to testify later today, and he can go into detail on the magnet testing program. But the scientists at the DOE and the National Laboratories are absolutely convinced that they will have a 60-foot magnet that is ready for commercial development in the very near future.

The CHAIRMAN. I thank the gentlelady.

We will now recess for about 20 minutes. We have to go. Four votes will be up in a row here now.

We want to thank Mr. Ritter and Mr. Barton, our colleagues, for their excellent testimony.

When we return, we will start with Mr. Joseph Salgado, who is the Under Secretary for Energy.

[Recess.]

The CHAIRMAN. The Committee will reconvene. As an interim piece of business we have to do, I ask unanimous consent to reconstitute the Technology Policy Task Force for another period of six months with no changes in membership. They are: Buddy MacKay, Mr. Brown, Mr. Walgren, Mr. Valentine, Mr. McMillen, Mr. Price, Mr. Nagel, Mr. Hayes, Mr. Skaggs, Mr. Packard, Miss Schneider, Mr. Lewis, Mr. Henry, Mr. Fawell, Mrs. Morella, Mr. Lujan, Mr. Mineta, and Mr. Roe.

No objections?

[No response.]

The CHAIRMAN. All those in favor signify by saying aye.

[Chorus of ayes.]

The CHAIRMAN. Contrary?

[No response.]

The CHAIRMAN. So carried. The motion is agreed to.

If we could run the place like that, you better believe that we'd get some of these things done.

[Laughter.]

The CHAIRMAN. Now, having said all of that, our next witness is the distinguished and Honorable Joseph F. Salgado, Under Secretary of the United States Department of Energy. We want to welcome you again, Mr. Salgado. We have your testimony and we will go ahead and proceed.

Mr. SALGADO. I would ask that the testimony be submitted for the record.

The CHAIRMAN. No objection. So ordered.

STATEMENT OF HON. JOSEPH F. SALGADO, UNDER SECRETARY, U.S. DEPARTMENT OF ENERGY, WASHINGTON, DC; ACCOMPANIED BY DR. JAMES F. DECKER, ACTING DIRECTOR, OFFICE OF ENERGY RESEARCH, AND GEORGE J. BRADLEY, JR., PRINCIPAL ASSISTANT DEPUTY DIRECTOR OF INTERNATIONAL AFFAIRS AND ENERGY EMERGENCIES

Mr. SALGADO. Thank you. I would like to make some brief comments, Mr. Chairman.

I appreciate the opportunity to come before this Committee and discuss the status and the importance of the Super Collider. It was 14 months ago that the decision by President Reagan to go forward with the Super Collider was made. Today the President and Secretary Herrington and the Administration still firmly believe in the importance of the Super Collider.

That decision 14 months ago was a decision not for today, but was a decision for tomorrow and the future of America for tomorrow. Past and present accelerators have changed the way that we live and our environment and our society. Based upon a proven record, the SSC offers valuable technical and scientific spin-offs for America and for the world.

It is essential, to maintain America's traditional leadership in the area of high energy physics, that the Super Collider is constructed and that we go forward. We at the Department believe, sir, that it is critical to future scientific and technological competitiveness.

The Super Collider will be built. It will be built in Switzerland. It will be built in Italy. It will be built in Russia. It may be built in the Far East. Or it will be built in America. I think there is a given in the high energy physics community and the scientific community that the super collider will be built.

The real question before us, the Government, is whether or not we are going to export our high energy physics community or whether we are going to import the high energy physics community and scientists in the world today.

Mr. Chairman, the 1989 budget shows that the SSC can be funded without adverse effects upon other scientific endeavors. Of DOE's $2.4 billion budget, $363 million submitted in 1989 are for the SSC. That represents an 18.3-percent research and development increase over the 1988 submission. But if you discount the SSC, you'll still show that there's a 10-percent increase in the R&D budget within the Department of Energy.

The question has arisen of whether or not the international community is interested in cooperating and collaborating in the development of the SSC. Approximately three to four months ago, Secretary Herrington sent a team to both east and west for informal discussions in the OECD countries to ascertain whether or not there was interest in the SSC, and the answer is in the affirmative.

As to actual commitments of dollars and cents, they are awaiting the decision of the United States Government as to whether or not we will go forward with construction of the SSC before finalized commitments can be made. As you are well aware, sir, last year

$10 million was requested for construction of the SSC, but it was denied.

We are currently moving forward on parallel tracks, both with the site selection process and the budget requests. I think it's important to note, particularly now that we have a best-qualified list, that the SSC will not be limited within the site. It will benefit both the region and the entire country as a whole.

There will be participation by thousands of businesses and workers in the construction of the SSC. It is expected there will be a consortium of 100 universities that have expressed interest in participation. And we believe in that one intangible, that the inspiration for future scientists of America will be well served.

Your support is critical. It is critical not because the SSC is to be located in a particular state. It is critical because it is the right thing to do for America. It is the right thing to do for America's future.

The SSC is the leading edge of technology, and with it rests our effort to maintain our competitiveness in the international arena, in expanding the frontiers of science and technology, and to ensure continued international leadership.

We welcome your focus on the SSC as a national priority and look forward to working with you and members of this Committee.

Before concluding, Mr. Chairman, I would like to thank this Committee, and Congressman Lujan, but you personally, for the time and effort you personally have put into understanding the dialogues that have taken place between the Department, this Committee, and yourself on the SSC. It's commendable.

And, last, I would like to compliment or pay tribute to the people of the National Academy of Science: Dr. Press, Dr. White, project director Dr. Kasper, and Dr. Frieman, the chair of the Site Evaluation Committee. It was a difficult process, and it was understood that it would be a difficult process before it was undertaken by the National Academy.

Because we all understood when it began that there would be those that would be on the so-called Best Qualified List and those that would not make the Best Qualified List. But, from our review and our analysis, the credibility and integrity we anticipated from the Academy was met at the highest levels. For that we are appreciative.

Mr. Chairman, that concludes my opening remarks, and I welcome any questions on any topics that you so desire, sir.

[The prepared statement of Mr. Salgado follows:]

Statement of Joseph F. Salgado

Under Secretary

Department of Energy

before the

House Science, Space and Technology Committee

March 22, 1988

Mr. Chairman and Members of the Committee:

It is a pleasure to be here today to discuss the Superconducting Super Collider (SSC)--the proposed next generation accelerator for the United States. I would like to take this opportunity to thank you for your interest in the SSC and your recognition of the Super Collider as a national priority. As the Committee is aware, President Reagan has submitted a request for $363 million for the Super Collider in FY 1989. Secretary Herrington is strongly supportive of this request and the commitment to the future represented by this project. Today I would like to discuss the importance of the SSC to continued progress in high energy physics research and to the Nation as a whole. In doing so, I will touch upon the SSC's potential impact on scientific and economic progress in the United States, issues related to the timing and funding of the SSC, and the substantial progress already made toward the development of the SSC.

The SSC will be the world's preeminent facility for high energy physics research. It will be a 20 trillion electron volt (TeV) on 20 TeV proton-proton collider, at the heart of which will be two rings containing about 10,000 superconducting magnets located in a racetrack-shaped tunnel that will be about 10 feet in diameter and 53 miles long. These magnets will focus and guide two beams of protons in opposite directions around the tunnel. The collisions that result when the two particle beams are boosted to nearly the speed of light and allowed to collide head on will create many different kinds of particles that will be detected and analyzed. The total project cost of the SSC is estimated to be $4.4 billion in FY 1988 dollars, including the costs of construction, R&D, detectors, computers and preoperations. In escalated dollars the total project cost is $5.3 billion. With an FY 1989 project start, the target completion date is 1996. I will discuss the importance of an FY 1989 start date in just a moment, but first let me comment on why we, as a Nation, need the SSC.

Need for the SSC

The SSC's energy level of 20 TeV per beam will be 20 times higher than the energy of the Tevatron collider in Illinois, the highest energy accelerator in the world. With this higher energy--which is similar to greater magnification power in a microscope--scientists will be able to explore the basic structure of matter and the nature of the fundamental forces far beyond the horizon of current knowledge. Although scientists working in high energy physics have made great progress in understanding these fundamental questions, many important questions remain unanswered. The quest for such answers places the SSC on the cutting edge of scientific exploration.

Each mystery unravelled along this path of research has dramatically altered the way we live, though often the consequences are not apparent for many years. Man's first steps on the moon would have been impossible without the basic conceptual understanding of gravity developed centuries earlier by Galileo and Newton. Radio and television and all the other electronic wonders of our age rest on the understanding of electricity and magnetism developed during the last century by Faraday, Maxwell and Hertz. Nuclear power and nuclear medicine can be traced to the quests in the first half of this century by Rutherford, Bohr, and Fermi for a deeper understanding of the atom and the nucleus.

Today, high energy physicists continue to be pioneers in the search for fundamental new knowledge. The frontiers they explore relate to those of other fields, especially astrophysics and nuclear physics, and advances in one field often benefit the others. The tools that have been developed-- high energy particle accelerators and particle detectors--have been used to enrich other sciences as well. Materials scientists, chemists, and biologists routinely use synchrotron light sources that depend on accelerators originally developed for high energy physics research. There are many other examples of applications of technology flowing from high energy physics in the areas of nuclear medicine, electronics, computer chips, superconductivity, and cryogenics. For example, it has been estimated that as many as 100 million Americans each year receive medical diagnosis or treatment benefits from nuclear medicine techniques which were developed from the technologies and particle accelerators used in basic physics research. Striking examples include computer-assisted tomography (CAT), positron emission tomography (PET), and magnetic resonance imaging (MRI) scans--the latter of which is estimated to be a multi-million dollar industry--as well as proton cancer therapy facilities such as the one being built at Loma Linde University Medical Center in California.

Although we cannot predict what applications will derive from SSC research or when they will happen, we can be confident that further advances in basic knowledge will contribute to America's economic and technological competitiveness through applications of the new knowledge gained and the discoveries made, and through technological spin-offs similar to those we have seen up to now.

Another important benefit of the SSC is that it will be a valuable training ground for American scientists and will attract many of the world's best minds and leading physicists to live and work in the United States. The SSC would be utilized by over 100 American university-based research teams, thereby continuing the precedent of accelerator facilities as a career launching pad for young scientists and engineers. The Super Collider would be a visible inspiration for young people to pursue careers in advanced science and technology by challenging a new generation to unlock the secrets of nature.

The SSC is essential if we are to maintain leadership in high energy physics research into the 21st century--with all of the many benefits I have just discussed. This is a field in which our country has excelled. In the past, U.S. leadership has been maintained by successive commitments to more powerful, sophisticated accelerators. The Super Collider represents the next generation of advanced accelerators. The technology to be used in the SSC is similar in principle to that of earlier, smaller facilities; but this technology will be advanced to higher levels of performance to achieve the most cost-effective and reliable facility possible. The technology developed in building the SSC and its experimental equipment is expected to lead to industrial innovation in many areas including superconducting magnets, cryogenics, computing and electronics. In this age of keen international competition, the SSC is vital to the United States' ability to maintain its leadership in the laboratory and the marketplace.

Technical R&D Achievements

Having summarized the importance of the Super Collider, let me take a few moments to discuss our progress to date in developing the SSC. Research for the SSC began late in 1983. This research has been conducted at leading high energy physics laboratories, universities, and industrial firms as a national effort coordinated by the SSC Central Design Group (CDG), which was formed under the auspices of a consortium of universities with an interest in high energy physics research, the Universities Research Association. The CDG completed the SSC Conceptual Design Report, which was thoroughly reviewed by the Department of Energy together with many independent experts. This process led to the conclusion that the project is technically feasible and that the cost and schedule estimates are sound.

We have confidence in these estimates for many reasons, including the extensive reviews by the Department and independent experts as well as four years of successful R&D. The continuing goals of that R&D program have been to explore cost-saving design features; optimize reliability, performance, and the overall integrated design of the facility; and ensure that the cost and schedule projections can be met. The Department has a well thought out R&D plan in place. This work has been successful, with a number of timely results.

Particular emphasis has been placed for the past two years on development of full-length 17 meter superconducting dipole, (i.e., bending) magnets for the collider rings and the advanced niobium-titanium superconducting cable used in their construction. Because the superconducting magnet systems of the collider account for about one-third of the SSC construction costs, these systems merit significant attention during the design and prototyping stages. The superconducting magnet R&D program has been carried out primarily by the strong and experienced technical staffs at three of DOE's established high-energy physics laboratories--Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (Fermilab), and Lawrence Berkeley Laboratory (LBL).

In the cable development program, LBL scientists have worked closely with U.S. industrial vendors to continue development of niobium-titanium superconducting wire plus its fabrication into insulated cable suitable for use in superconducting SSC magnet coils. The program has been highly successful in improving the current-carrying capacity by a factor of 1.5 compared to that used a few years ago for the Tevatron accelerator at Fermilab. This cable is being used in the magnets that are a part of the more advanced magnetic resonance imaging systems currently in use in hospitals across the country.

Substantial progress has also been made in the magnet development program--which is further advanced than is typical for high technology projects at this stage. The technology of superconducting magnets is advancing rapidly, driven both by our SSC R&D and by foreign accelerator projects. We want the most advanced, cost-effective, state-of-the-art magnets to be available for the SSC when we have to lock into a final design a year or two from now. Rather than using a more conservative and costly design, we are still pushing the technology and making progress.

We anticipate a magnet design that meets all requirements of the SSC collider to be finalized in the first half of 1989. That design will be used by industry to develop tooling and assembly methods. We hope to be able to start the magnet industrialization program soon with a transfer of information among the involved laboratories and experienced industrial firms. The Department anticipates that several vendors will be qualified to produce SSC dipole magnets by the end of the magnet industrialization process and that they will have developed appropriate tooling to proceed with production of the 8000 dipole magnets that will be required. Under this plan, mass production of dipole magnets will begin in 1992.

FY 1989 Request

Fiscal year 1989 will be critical for the SSC project. The careful planning and intensive R&D phases of the project will be ready to expand rapidly into the first construction activities of the eight-year SSC project. One of the most important activities for the SSC is to transfer SSC magnet technology to industry and to establish commercial sources of superconducting magnets. To do so requires both an enhanced R&D program and a major construction start.

As mentioned earlier, the total FY 1989 request for the SSC is $363 million. The request includes $64 million in Operating Expenses. This will permit R&D on the SSC technical systems to proceed at the substantially enhanced level in FY 1989 that is necessary to meet the project's requirements. About two-thirds of the request will be concentrated on the magnet R&D and magnet industrialization effort. The $16 million Capital Equipment request will provide equipment required to support the magnet R&D program for testing and analysis of magnets and for testing various other technical components and systems.

The Construction request of $283 million for FY 1989 gives the highest priority to the early phases of engineering design and long-lead procurement of critical items. A substantial start on engineering design of the main collider rings is an essential prerequisite to placing orders with industry. The request, which will allow initial construction activities to proceed on a broad front, includes $39 million for detailed engineering design of technical systems and conventional facilities, $60 million for long-lead items for power stations and utilities distribution systems, $27 million for site preparation, $55 million for injector technical components which are early critical path items, $65 million for long-lead procurements for collider components and $37 million for project management, support equipment and rental space.

Cost-Sharing

When President Reagan endorsed the construction of the Super Collider, he was fully cognizant of the existing budget constraints. Nonetheless, he was not willing to forego or delay this important investment in our Nation's future.

In light of those constraints, we are committed to building the SSC without compromising funding for the other sciences. To accomplish that, we are seeking maximum cost-sharing internationally and from industry as well as state and local sources. International participation is the most promising potential source. The SSC is a priority project for the international science community; and the U.S. expects substantial participation from many countries.

In January of this year, Secretary Herrington sent two high-level delegations to Europe, Canada and Japan to present briefings on the current status of the project, reemphasize the Administration's commitment to the project, and discuss the opportunities for foreign participation. In addition, the teams were open to discussion of proposals or issues relating to participation raised by individual countries. The response to the team visits was very positive in all cases. There is a high level of interest in the project on a scientific level, and all countries visited stated their desire to participate in the utilization phase. In addition, many of the countries indicated a strong interest in participating in the design, manufacturing and/or construction phases on both the scientific and industrial levels.

Only by assuring our allies that the project will proceed into the manufacturing and construction phase, can we realize their contributions at the earliest possible time; and, in return, their skills and expertise, both within scientific communities and within industry, will ensure the earliest possible completion of the project. The downpayment on the project represented by the FY 1989 budget request seems a reasonable price to pay for the economic, technological and scientific benefits which would flow from it.

FY 1989 represents the first year of substantial funding for the Super Collider. In the five-year period between FY 1988 and FY 1993, excluding funding for the SSC, there is still a projected increase in DOE's other basic science research activities of over 34 percent. This is an average annual increase of over 7 percent. In this same period, the budget for the National Science Foundation is projected to increase by almost 76 percent; and the budget for the National Aeronautics and Space Administration is scheduled to increase by 67 percent. This latter increase reflects another Administration initiative--the space station. These numbers clearly show that the SSC is not being funded at the expense of other science. Rather, it represents only one part of a very broad Administration effort to advance in all areas of science. This approach recognizes the very substantial role that scientific research plays in our economy and in enhancing the quality of our lives.

Site Selection Status

The Department's formal site selection process for the SSC is proceeding as planned. It began in April 1987 with the issuance of the Invitation for Site Proposals (ISP). By the deadline of September 2, 1987, the Department had received 43 site proposals from 25 states. All proposals were screened by the Department against the previously established qualification criteria to determine which were to be considered further. On September 17, 36 qualified proposals were forwarded to an expert committee of the National Academies of Sciences and Engineering for an independent evaluation based on the technical criteria and cost considerations specified in the ISP.

Following detailed review and analysis of the qualified proposals, the Academies provided the Department with a report of their evaluation, including an unranked list of its recommended best qualified sites (BQL). The Department then reviewed and validated the Academies' report and accepted their recommended best qualified list of eight sites without modification. Subsequently, the State of New York withdrew its Rochester site proposal. On January 19, 1988, Secretary Herrington announced the final list of seven best qualified sites: Arizona (Maricopa site), Colorado, Illinois, Michigan (Stockbridge site), North Carolina, Tennessee, and Texas (Dallas/Forth Worth).

The National Environmental Policy Act requires that an environmental impact statement (EIS) be prepared for major federal activities that could have a significant impact on the human environment. We are in the process of preparing such an EIS for the Super Collider and have recently held public scoping meetings at all seven BQL sites. At these meetings, the Department sought public comment and participation in identifying the scope of the environmental issues to be addressed. In parallel to preparing the EIS, the Department will continue to evaluate the seven proposals. Current plans call for visits by Departmental officials to the seven sites in the Spring to clarify specific areas of each state's proposal and to tour the site. The preferred site is expected to be designated in November 1988, with the final site to be announced in January 1989 following completion of the EIS process.

The Imperative to Start Now

Because of the long time required to plan, design, and build high energy physics facilities, planning to assure continuity of the research must proceed in parallel with the effective use of existing facilities. The current U.S. frontier accelerators will have explored much of the science accessible to them by the mid-1990s, and the SSC will be needed to continue exploratory studies well into the next century. The SSC is technically achievable by the mid-1990s.

The time scale appropriate for construction is set not only by the scientific need but also by the need for cost control The planned project duration of eight years is already long on the time scale of technical projects. The duration needs to be limited to assure continuity of the management and its driving energy and vision.

Government support of basic research has helped to produce many of America's unparalleled scientific achievements in this century. The Super Collider is an investment in the Nation's future--an investment we must make today. I believe that the SSC demonstrates clearly the commitment of the Reagan Administration to pursue new initiatives in science and technology and, in doing so, to enhance the economic and technological health of the United States.

As President Reagan stated in his Legislative and Administrative Message to Congress in January, the Super Collider is "essential to continued United States leadership in high energy physics and America's scientific and technological competitiveness." It is critically important that Congress move ahead this year with a strong commitment to this project as a delay could represent a tremendous lost opportunity for the Nation's competitiveness and an abdication of our half century of leadership in high energy physics research.

Construction of the SSC will help keep this country on the leading edge of basic science research well into the next century. By the middle of the 1990's, current accelerators in the United States will almost certainly be eclipsed by the newer European and Soviet world-class particle physics machines scheduled to go on-line at that time. Failure to build the Super Collider in the United States will represent an abandonment of our scientific leadership in a field of physics dominated by Americans for virtually the entire twentieth century.

It is my hope that the Committee will recognize the tremendous importance of the Super Collider to the Nation--and the promise it holds for continued United States world leadership in high energy physics and for enhancing technical competitiveness into the 21st century--by supporting the President's funding request.

That concludes my statement. I would be happy to answer your questions.

DISCUSSION

The CHAIRMAN. The Chair thanks the gentleman for his presentation. I trust there will be questions asked of you. Some I will ask myself.

I want to go on a little different tack, however, because in our communication to you under date of March 14, we said, please be prepared to discuss the over-all status of the SSC project, the nature of the site selection process including the interaction with the NAS/NAE Site Evaluation Committee, and the results of the debriefing of States not on the Best Qualified List.

I know that you have a paragraph related to that in your statement, but I think there's a question of credibility that is arising. And, if we're going to deal with this, I'd like to deal with things right on the deck, up front, and either put it to rest or bring it out. Whatever the case may be.

Now, having said that, I think it might be helpful for the Committee— In other words, could you describe the functions of the Department of Energy Site Selection Task Force? Could you give us just a little run-through?

I think it would be profitable. As assiduation starts to mature—for the want of a better phraseology—more attention is being paid to this whole issue.

Now, some of the States have come back— And I'm simply the carrier. Don't kill the messenger here. I usually kill the messenger.

[Laughter.]

The CHAIRMAN. The point here is basically that there is a question as to whether or not the process was carried out properly. Were the proper people notified? Did we have the proper criteria? Did you even look at the criteria that this Committee wrote, the additional criteria, into its bill that it was going to take to the floor?

These kinds of things we want to get on the record. So, if you'd like to go on that, we'd appreciate it.

Mr. SALGADO. Okay. Well, let me address that a little bit and, if I miss some of the salient points, you can address those in particular.

Let's take a look at the site selection, the task force that was set up, and let's look at the criteria that were established, because that's of focal interest. I believe it was in 1985 that a proposed invitation for solicitation proposal, and the criteria were laid out. It was in 1985, and this was disseminated to all 50 States, as to their comments on the criteria that was going to be laid out.

Last April we established the criteria in what is referred to as the ISP, the Invitation for Site Proposals. This was sent, and of course, everybody was notified of the criteria, the weighting factors of those criteria, and how these criteria would be valued against the proposals that were going to be submitted.

There was a preproposal conference at which 300 people entertained and came in and made various comments. And, essentially, the criteria was laid out by the Site Selection Task Force incorporating various comments from various components, and it was put forth in the ISP.

During that course and time, I believe, sir, of the entire selection process and the development of proposals, and post-time, I do not believe at that time that there was a significant issue raised as to the criteria or to the weighting of that.

The CHAIRMAN. Will the gentleman yield?

Mr. SALGADO. Yes, sir.

The CHAIRMAN. In October of last year this Committee issued H.R. 3228 with an accompanying report that delineated the sense of this Committee on essential ingredients that must be incorporated into authorization of this project.

One such issue related to life-cycle costs and weighting factors associated with these costs. In subsection 102(d), the Secretary is directed, in determining the over-all ranking of each site proposal, to give 75 percent of the weight to the technical evaluation criteria, and the remaining 25 percent of the weight to the life cycle costs.

It appears that this Congressional concern has been totally ignored in the site selection process. The National Academies of Sciences and Engineering, citing panel guidelines, certainly ignored H.R. 3228 recommendations.

In essence, the criteria that were used in the weighting were identical to the first issuance of the amended criteria that followed the Domenici amendment. And, therefore, on that basis, which raises our concern, we did make that point known as to what the concern was. And we held considerable hearings on that issue. But then it was as if it didn't happen at all.

Mr. SALGADO. I don't believe it was that it didn't happen, sir. I believe at that particular point in time the ISP was in proposal status. Number one. Essentially, that it did not become a matter of law as the Domenici amendment did, which mandated an amendment to the ISP at that particular time. And, though it was looked at, sir, it was determined at that particular time on the 75 to 25 percent weight.

Now, there was a consideration given at that particular time as to establishing that band. And I believe we had several discussions concerning that band of a 10 percent, so that the life-cycle costs would not become an overriding factor in the determination of the site selection process.

The indication of that band of 10 percent, I believe, was in response to your concerns and other concerns of the members, that essentially that the life costs could become an overriding factor and therefore detract from the technical merit of a proposal site.

The CHAIRMAN. If the gentleman would yield.

Mr. SALGADO. Yes, sir.

The CHAIRMAN. Let me ask you a question. Does the Department of Energy believe they need any further enabling legislation, authorizing legislation, to do this project at all?

Mr. SALGADO. Of course.

The CHAIRMAN. All right. It would seem to me that, if the Committee holds intensive hearings and then it speaks after quite a fierce debate, the Committee then feels it was completely ignored or at least what they were doing was ignored. You said, "Well, it didn't become law."

Let me get on the record why it didn't become law. I think that's important, because I think it's important what's going to happen right now in the debate that's going on. Right now. The budget debate.

The feeling was that here we have a project that's $4.5 billion. The feeling was—and you've heard some of the Members speak here today—that we can't afford to do this. And, although we had overwhelming approval of the Committee, as you know, on the H.R. 3228, it was decided in council to hold that up at December of last year, because it would have come a cropper on the whole reduction situation as far as the legislation was concerned.

That didn't mean that the Committee was abrogating its position or changing its position. It said that there was a time politically to use the proper accord and not to. That was not the proper time. In which case, the matter was held up.

We had asked the Administration, for the record, not to go ahead with the preliminary site selection or the preliminaries. To hold it up until we could get a reaction from Congress. But the Administration, in candor, just ignored that particular request.

Now, consequently, we are coming back right now and we're saying that it's going to take a great deal of effort and energy on a lot of people's part to make this happen at all, as the thing is going. I'm sure you're aware of that.

So, what the Committee wants to get cleared up is some of the issues we put out. The 75 percent of the weight to the technical evaluation criteria and the remaining 25 percent of the weight to the life-cycle cost. From what we've been able to ascertain and all we've been able to get, including this particular document, is that it doesn't seem to have followed that direction.

And we've got now Members who have been debriefed by DOE, as you're well aware, and who have come back and they're questioning the whole process. So, I hope that we can start to clear that up a little bit today.

Mr. SALGADO. Well, Mr. Chairman, I would like to. I believe that we had personal conversations indicating your concern and we were aware of the legislation. And at that particular time we felt that that 10-percent band that was put in the life-cycle costs, that would not pursue exactly your 25-75 percent ratio, but was sufficient to take care of those concerns of the Committee.

Now, to say that we ignored them, they were considered, sir, and there may have been changes or we may have made mutations in this process that we thought were beneficial to the process. But I don't think that we ignored your concerns.

The CHAIRMAN. The gentleman from New Mexico.

Mr. LUJAN. Thank you very much, Mr. Chairman, and welcome, Mr. Secretary.

I'm concerned about lack of credibility. As you know, I'm a supporter of the Super Collider and I will do everything that I can to get it built, and even after the short list and everything. That has not affected my support.

There is, however, a big question in my mind as to how we arrived at this. And I'm not going to beat a dead horse, now. It's gone. But I just simply want to tell you that I'm not very comfortable with the way that this decision was made, and I'm not the only one.

Let me tell you why I don't think that this whole thing turned out that it was not done in a very good fashion. I've gotten briefings, our entire delegation has gotten briefings, from both the National Academy of Sciences and DOE. And, while everybody, you know, tries to assure us that everything was taken into consideration, it just doesn't appear to me to be the way that it should have been done.

DOE started off by telling the National Academy of Sciences that they ought to have 15 distinguished scientists and engineers and other individuals, and those that are appointed were to give due consideration to potential real or apparent conflicts of interest and geographical distribution.

We look at the composition, first of all, and it's not 15; it's 21. That's not a big deal, but that's a 40-percent increase. So, right off the bat, we didn't follow the guidelines.

Geographic distribution, there were seven total that had— There were six of the committee members who were from California, and then another one had recently moved from there. So, that was seven out of the 21, one-third of them from California.

Now, you're going to say, well, California didn't get it. So, therefore, that means it was unbiased. It might be just the opposite. It might be that— You know, we all don't want to be criticized. So, it might be that they bent over backwards, and maybe California got the shaft on the thing.

Geographical distribution, again. Most of the sites, or many of the sites, were for rural areas. Yet, only one was from an area that is not a metropolitan area of over a million—Let me back up. Only one was from a metropolitan area of less than 100,000.

Now, it seemed to me, because of the comments that were made to me, that the committee really did not understand the nature of rural sites. Because one of the things that they told us was that, well, New Mexico didn't qualify— And I just use that example. I'm not crying over spilled milk, now.

New Mexico really didn't qualify because the area is remote. It's far away from Albuquerque. Well, anybody that says that doesn't really understand that 15 miles or 20 miles is not outside of the city. We travel a hundred miles just to go to dinner.

[Laughter.]

Mr. LUJAN. So, it's like saying, well, you know, you got to go all the way to Alexandria to do something. So, it shows that there wasn't an understanding of some of the sites that were proposed. Because all of the sites are close to large metropolitan areas of a million or more.

And, then, finally, there's the appearance of a conflict. Fifteen out of the 21 have some connection with the URA, which runs Fermi. And I'll just leave it at that.

So, it just appears to me like there just isn't— You know, you hate to criticize the National Academy of Sciences. They're all good friends of ours, and all very dedicated and very professional. But it just seems to me like the ones that were appointed to make the decision weren't really aware of what makes things tick in different areas of the country. It seems like a predecided question of what the committee was looking for.

And, then, when we got the briefing, first of all, we didn't get the same briefing from DOE and NSF. One didn't know how the other— I mean the National Academy of Sciences. I'm sorry. Frank, I see you there, and I see NSF, and National Academy of

Sciences when you were over at NSF, and that's why I'm getting confused about it.

But we got different reasons. For example, we were told that one of the reasons that we were not selected was because we're not a big transportation corridor. It's hard to get in and out of Albuquerque. Let me tell you, Joe, I've got 21 flights out of Washington to Albuquerque every day that I can choose. Well, maybe not quite as many coming back, but just pretty close to that.

[Laughter.]

Mr. LUJAN. But we're told that it's hard to get to Albuquerque. Well, it isn't.

We were then told that the city is too small, because the wives and children and husbands of those that will be working there— God, I'm glad I mentioned that. Spouses of those that are working there can't find a job in the area. Well, we have Sandia there. They've got 7,000 employees, as you know. And the spouses all work, and they're professionals and the same kind of people.

So, it just seems to me like there was not an understanding on the part of those who made the decision. We asked how was that decision made. Well, you know, everybody—unanimously, I guess— It's rather strange. You know, you take 35 sites. For eight of them, everybody raises their hand. And for the others, not all eight of them. You know, that kind of stretches credibility a little bit.

So, I guess maybe I raise these things because there will be other projects in the future, and maybe there's better ways of doing it. You may say whatever you want.

Mr. SALGADO. Well, sir, I appreciate it. I would make a couple of general comments. I can understand your feelings and I've had the opportunity, if not the pleasure at times, of personally meeting with other non-BQL site delegations. So, I understand the concerns, and yours are not the only ones, sir, that have been raised.

I think that the selection of the members of the committee themselves, though they went from 15 to 21, is that, once again, we sought and, when we asked the National Academy to do it, we knew that they would bring in the best qualified and the most competent they could to do this task. And we knew it was going to be a difficult task to do.

I think that the question of whether— I've flown into Albuquerque several times, as you're well aware. So, I find access and egress very accessible.

As to the appearance of conflict with URA, I would like to just mention this, because this has been a sensitive issue. I think that it should be noted that there is a small world of high energy physicists out there. It's not a common scientific discipline, so there's a small world. So, obviously, many of the people that are involved know this.

And part of the expertise— And I'm speaking on behalf of the Academy. But part of the reason, of course, is the lessons learned from the selection of Fermi, lessons learned from how they went about this process and how we integrated ourselves into the Fermi selection process as well as the construction. And I'm sure that the Academy can answer it best, but there was a limited amount of expertise, and it was valuable expertise that we had to touch and go to.

Congressman Lujan, I guess the only other point that I would make is that there is probably no perfect process for us to address this issue, because, obviously— I don't think anybody is saying that, hypothetically, New Mexico was a bad site. But I think what we're really saying, and what the Academy and what the DOE is saying, is that, the best-qualified sites, that basically New Mexico didn't make it on that list.

We're not saying it's a bad site. We're not saying that it couldn't, quote, unquote, be built there. But what we're saying is that, as an obligation to this Committee, to each member, and to the Congress, that we had to come up with a list of the best-qualified sites we could.

It's imperfect. Everything we do in human endeavor is imperfect. And we went to the place where we found that we were assured of the most credibility, the integrity, the competency, and that we could not be accused of a political decision to get to this Best Qualified List.

And we dealt with the Academy at arm's length as they went about their process, because we had confidence in their integrity and their credibility. And it's not perfect, sir, and I hear your concerns, particularly those on rural America, because I've heard those in other delegations for other sites.

But we laid out the criteria, we gave it to the Academy, and we entrusted them to go forward with it. And, through our validation process, we believe they did it in an extremely credible manner. It can't please you, and it can't please other Members of this Committee and other Members of the Hill.

But, believe me, that if there is an appearance of a problem there, it is only an appearance. Because we have gone to every effort that we could as a Department, and I know the Academy did, to ensure that, as the Secretary said, this was a level playing field and there was an opportunity, and everybody had a fair opportunity to it.

And, as far as the reverse discrimination with California. You know, coming from California, I at times also had some disagreements about what goes on that Best Qualified List. But basically we stand behind the Academy and our own validation of that. But I do take your comments seriously, sir. Thank you.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from California, Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman. Mr. Secretary, it may be a surprise to you but I think that I agree with you that the site selection process has been conducted as objectively and as fairly as possible.

I've said that from the beginning and I continue to say it. I have great faith in the people of the Academies. They certainly would do better than any 15 Members of Congress, and I think out of those seven best qualified would get a very good site. It's bound to be better than Geneva without any question.

I have some relatively brief questions. You, in your statement, mention the R&D program the Department is carrying on with regard to cost-saving design features, and you elaborated a little bit on the magnets, and the cable, and the wire fabrication and so forth.

How much do you think the R&D program might be able to produce in terms of savings in those areas which I think you said represent about a third of the cost?

Mr. **Salgado**. Mr. Brown, I'm going to ask Dr. Decker to join me at the table here as the Acting Director of Energy Research and see if he can address that topic for you, sir.

Dr. **Decker**. In starting out to develop the superconducting magnets, of course, we had a very solid base to work from from our experience at building the Teratron accelerator from superconducting magnets.

But, we wanted to try to improve on the design so that we could reduce both the construction and operating costs of the SSC. So, we set out to increase the field strength for the magnets by about 50-percent, increase the current-carrying capability of the superconducting cable by 50-percent, also to reduce the heat loss by about a factor six.

We have been, I think, very successful in that R&D program in terms of achieving those objectives. We have built magnets in one-meter length and four-meter length which have been very successful in meeting those goals. We are now working on 17-meter magnets, full-length magnets.

We have met most of our goals. We still have what I think are minor problems that need to be overcome, but I think we can do that within the next six months.

Mr. **Brown**. Will you report to us within the next six months that you have successfully overcome these? We've been through magnet manufacturing problems before and we didn't meet our expectations in that regard.

Dr. **Decker**. Yes.

Mr. **Brown**. May I inquire as to whether your research, with regard to the fabrication, has included any research into automated manufacturing? There is one hell of a lot of wiring in these magnets and it impresses me when I look at them. I was wondering if we couldn't do something to improve the quality of American manufacturing as part of our research program here?

Dr. **Decker**. Certainly, that is an important thing to try to be able to automate the manufacture of these magnets. We have done some work in that area in terms of developing winding machines to do it. We probably need to do more at this point.

Mr. **Brown**. Let me ask you about two other things that I'm interested in. The tunnels, this will be a very large tunneling job, one of the largest I guess, and there's been a lot of progress made in tunneling technology.

Does the Department's research program include any efforts at improving on tunneling technology which can have considerable spin-off benefits in other areas?

Dr. **Decker**. We have not supported any research, to my knowledge, in that area.

Mr. **Brown**. How about what I think are called radio frequency cavities, the parts of the ring that give the boost to the protons? I'm told that those represent a significant cost to the operation and that there are some economies possible in that area. Does the research program include any work on that?

Dr. **Decker**. Yes, it does, sir.

Mr. BROWN. And do you anticipate you may be able to achieve some additional economy, sir?

Dr. DECKER. I don't know what the prospects are of achieving additional economies over the present design, but it certainly is an area that we're working on.

Mr. BROWN. Thank you. I have no further questions, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Illinois, Mr. Fawell.

Mr. FAWELL. Thank you, Mr. Chairman. Mr. Salgado, I note that on February 24, the Department of Energy requested that Congress allow the transfer of $8 million from the Department/Administration appropriation to the High Energy Physics Program, the General Science and Research appropriation to permit work on the SSC "to proceed on schedule."

That apparently has not been successful, is that correct?

Mr. SALGADO. As of this date, it has not been successful. We are continuing to work the problem and have had various discussions with Members of the appropriate Committees on that issue.

Mr. FAWELL. Do you feel that you may be successful in the near future on that?

Mr. SALGADO. I am hopeful that we will be. It is an issue that we have to continue to work and it is a problem, part of a problem of our own self-creation in that the Secretary has been personally involved and met with various people and will continue to do that.

I have hopes that we will, sir, but I have no assurance.

Mr. FAWELL. If the funds aren't forthcoming, what will be the effect?

Mr. SALGADO. The effect of a lack of reprogram ability of $8 million in this fiscal year has two impacts. Number one, it has an impact of delaying the research and development in the magnet activity; it has the impact of one of the cost factors in the site selection process that is extensive is the Environmental Impact Statement in the hearings, it may cause that to slide into further time periods.

It has the impact, at the same time, of possibly slowing down the site selection process. So there are a whole series of options or tradeoffs within the amount of funds that we have in this line right now that could be impacted by the lack of that $8 million for reprogramming.

Mr. FAWELL. Would that possibly affect determining the final date to make the selection?

Mr. SALGADO. They could if the Secretary so made that decision that it could affect both the preferred date and the final selection date if the Secretary made that decision.

One of the options is to continue on, get the preferred site, but because of a need to elongate that process on the EIS, that the final selection, of which you're aware, is contingent upon a final EIS report, may slide beyond the January timeframe.

So, there are many repercussions that could flow from this $8 million.

The CHAIRMAN. Will the gentleman yield at that point?

Mr. FAWELL. Yes.

The CHAIRMAN. For the record, could you tell us why the Department decided you were so rigid on your first date in December was it, or early January, that particular date to narrow the list down? What happened that the time went all the way to November?

Mr. SALGADO. Well, the original schedule, Mr. Chairman, I believe, was in the July time-frame. There were three events that basically we decided to move it beyond into the November time-frame. Number one we had, I would say, a large outpouring of participation in the first Scorpion hearings and so the decision was based upon number one with the IS/EIS hearings and being public, there would be an opportunity to incorporate the comment from the public into the final decision process, number one. And that had not been factored before.

The CHAIRMAN. Though we had brought that up at the hearing, if you recall.

Mr. SALGADO. Yes, I recall that, sir. I think the second point is that, besides allowing that, is that we made a determination and notified the proposer States approximately a month ago, that many States were very interested and the fact of the matter is that this process with the paper process and that the final selection official was Secretary Herrington, but there was not an opportunity to interface at that particular time.

We have made a decision to be given the additional period of time here that the proposer States will have an opportunity to come in and, before a decision is made, have an opportunity to meet with Secretary Herrington and make a proposal. So, there is an opportunity now factored in this for proposer States, before the final selection, will have an opportunity to sit down and meet with the source selection official and discuss the reasons why they personally believe that their State has an opportunity, or should be selected, as the best qualified as the preferred site.

So, there were several factors there that—number one, the comments, the EIS be able to factor those in and give us time for better in-depth analysis on our site visits, which are going to occur in the next eight to ten weeks, as well as this opportunity for proposer States to come in and meet with the source selection officials so there is at least a face to face opportunity for each proposer State to come in and have a dialogue with the source selection official prior to that decision being made.

The CHAIRMAN. Will the gentleman hold at that, will the gentleman yield further? Is that, it is my understanding that once the academy made the first basic recommendation, the academies no longer consulting with you as to what the Environmental Impact Statement or the issues involve?

Mr. SALGADO. That's correct.

The CHAIRMAN. That's now strictly an agency determination within the Department of Energy?

Mr. SALGADO. Within the Department at this particular time.

The CHAIRMAN. Within the Department itself?

Mr. SALGADO. Yes, sir.

The CHAIRMAN. The gentleman from Illinois?

Mr. FAWELL. The only other comment I would have is I think that you have a tremendous task trying to satisfy everyone obviously in the site selection process and I guess I can only say that, in all that has happened, with the ups and downs, that the one area that I would have—did have, as some of you may recall, I did make telephone calls and I think yelled at a few people for which I am sorry now, but when the Domenici amendment came into being, that to me still makes no sense because in the final analysis it says you're going to have to make that final decision in the life-cycle costs without knowing what the life-cycle costs will be.

You really don't know because it's supposedly pegged away in a sealed envelope, so you make your final decision not knowing, indeed, what the costs will be.

I would hope that somehow that can be altered; perhaps Congress is feeling a bit differently now because of the fact we know we do have this budget crunch, and we should take into consideration every possible, I think, cash or in- kind contribution that may be there.

Perhaps it would, looking back, perhaps it would have been better just to have made the selection and then gone ahead with it. I think I, all in all, I've got to say to you, you have a very difficult job. You won't be able to satisfy everyone, obviously, but I think I'm satisfied at least and you have certainly gone along and done the very best you can.

Mr. SALGADO. Thank you, sir.

The CHAIRMAN. The Chair recognizes seeing the gentleman from North Carolina, Mr. Valentine.

Mr. VALENTINE. Thank you, Mr. Chairman. Mr. Secretary, I'm advised that our staff, Committee staff, was informed that the DOE evaluations of the site proposals lead to conclusions which are similar to those reached by the academies. My question is, the first question, were there any discussions among the site task force personnel and the National Academies of Sciences and Engineering personnel during the site evaluation process?

Mr. SALGADO. If I understand your question correctly, sir, during the National Academies endeavors and their analysis prior to their conclusions of the mission of their Best Qualified List, the Department of Energy dealt at arms length and our people did not participate in that discussion process at all.

Mr. VALENTINE. So, you're saying the similarity of the conclusions would be a coincidence?

Mr. SALGADO. The conclusions that were arrived at both through the National Academies and our process, I think it should be understood that the process undertaken by the Department of Energy was a process of validation of the National Academies Best Qualified List, that the criteria had been followed and there was a rational underlying basis for the decisions that came forth from the National Academies, to have satisfied ourselves through dialogue with the National Academies after the list was generated, but in fact, the criteria were adhered to, they were consistent, and that therefore, we understood the rationale for their selection process, and therefore, validated that process.

Mr. VALENTINE. Why did the Task Force relegate cost factors to such a low priority among the technical evaluation criteria, especially given these times of hard budgets and Graham-Rudman and that sort of thing?

Mr. SALGADO. Well, I think that, obviously sir, that in hindsight there may be some differences of opinion.

I think the first issue here was if this is going to be a commitment by the United States Government to go forward, then I think of the maximum importance was success, the fact that if we were going to build this SSC, that it would be successful and meet the expectations that this Congress and that the Administrative Branch needed.

The second point was to pick the best site possible in order to ensure that success, and therefore, the life-cycle costs in and of themselves, could not become a dominating factor because it may have been cheaper hypothetically to build it in, if nobody's here, Antarctica or someplace; it may have been cheaper to build it someplace like that, but we may not have been able to ensure the success of that.

So, we did set up a series of criteria and as a footnote, Mr. Valentine, I would also indicate that I had occasion to go back and look at these criteria that were laid out for the Fermi laboratory, and their criteria pretty well stand up to the criteria that were laid out for the SSC. I don't say it's bad, I don't say it's bad or good because of that, but I think that the overriding concern was that if we're going to commit the American taxpayers' dollars for this project that we have to have success in it and we did not, we needed the best qualified site, not necessarily the cheapest. And so, the life-cycle costs then fell down to a lower ranking, and that was a decision made by the Department, sir.

Mr. VALENTINE. Let me ask you one final and more mundane question. Every time there is an improvement which benefits a majority, a large number of people I suppose the construction of new highway, gymnasium, school, government building, it requires in many situations the appropriation of private property, securing real estate owned by individuals under the power of eminent domain.

I don't see anywhere in the criteria that anything about that and that detail, and I wouldn't expect to. My question is, in the selection process, what credence, if any, do you think will be given to the site selection committee if the people in one area seem more reluctant and scream louder, those people who are going to lose their land, who might lose their property?

Mr. SALGADO. Well, I would hate to speculate. I think that it's obvious from the New York situation that essentially there was enough screaming and yelling loud enough that they decided to withdraw a proposed site. I think that one of the underlying factors—

Mr. VALENTINE. Excuse me just a minute, but that was an action on the part of the State of New York.

Mr. SALGADO. Yes it was, but the local people are the people that basically generated enough interested, raised enough yelling and screaming, that basically the political structure there determined that they did not want to be considered.

As to address your concern is that one of the underlying premises I believe that we went into this proposal process and asked for proposals from the various States, but the fact that the States had to ensure that basically the land would be available to the Federal

Government if this project was selected to go to that particular issue.

How much basic weight is given to it? I think that our job is to look at the proposal that has been submitted and to ensure that that, and to do an analysis of that proposal. Obviously I think that when this oral presentation is made before the Secretary, there will be an opportunity at that particular time for people to basically either to indicate the massive support in the communities and why it's needed there and why it's wanted there; there will probably also be an opportunity from the letter writing campaigns that have already taken place for people to express their displeasure.

But, we don't have an actual weighting factor as to that.

Mr. VALENTINE. Well, let me just ask you a little bit differently now, then I'll be through, Mr. Chairman. What weight will be given to, aside from the other criteria, to support? You know, some people are better at generating a Chamber of Commerce atmosphere. When it comes down to it, how much credence are you going to give to that kind of hoopla?

Mr. SALGADO. Well, having run other sites, Mr. Valentine, I'll tell you that support is important to any place you put a facility, believe me, but this is not with the SSC.

It is part of the regional resources and it's low on the criteria, on the evaluation process. I'm not sure which number it is in the weighting process, but it is laid out there to the communities for it. If I could have a moment, sir.

It's a sub-criterion of the number two criterion, so it means that it has some weighting, it is a sub-criterion basically of probably eight or nine down, and under two or three down in regional resources, so it will be considered but it is not an overriding, it is only a sub-part of a larger criteria.

Mr. VALENTINE. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentleman from North Carolina. The Chair recognizes the distinguished gentleman from Michigan, Mr. Pursell.

Mr. PURSELL. Thank you, Mr. Chairman. I'm not a Member of the Committee, but I do serve on the House Energy and Water Subcommittee, which will do the funding.

I just want to take one minute and thank the Chairman for first entering my testimony in the record today, and had I stayed on Science and Technology today I would be replacing Manny Lujan as the Ranking Republican, and I regret now, maybe, that even though I went to the Appropriations Committee, this was a great joy, a real love of science and tech and I'm sure that Chairman Roe and Mr. Lujan and others are going to see that this project moves forward since I do come from Michigan.

The CHAIRMAN. The difference is you got the money.

Mr. PURSELL. My guess is, Mr. Chairman, if you go through the process of a great hearing and I'm very delighted that you did make that decision, and secondly if you do mark up and the fact the Budget Committee has about $100 million, we'll probably fund it at that level, pending your decision to mark up and what you do in our time table with only about four months to work. You've got April, May, June, and July and then we're going to break for conventions and the election, so we're going to have a real squeeze on authorizing an appropriation coming each year, clashing in terms of timetables. But, it would be nice if you could get an authorization bill to the Floor so we'd have a full debate on the merits of the issue, not just the funding.

So, today is an excellent opportunity for you to present the scientific substance of the issue. It's not a jobs bill, it has enormous physics implications to the whole scientific community in the world. So, I congratulate the Chairman and I hope to be helpful on the Energy and Water Subcommittee and not just for Michigan, but for the sake of the project. I think it has enormous potential for the world scientific community. Thank you. I yield back the balance of my time.

The **CHAIRMAN**. I thank the gentleman. The Chair recognizes the distinguished lady from Rhode Island, Miss Schneider.

Miss **SCHNEIDER**. Thank you, Mr. Chairman. Mr. Salgado, I would like to get back to one of the points that you made earlier in your testimony, having to do with some of the different countries that you said had indicated that they were very interested in participating in the design, the manufacture, and/or construction phases. I wonder if you could share with me some of the specifics as to, for example, which countries said what?

Mr. **SALGADO**. I can indicate the countries that Dr. Decker and Mr. Bradley went to. As to the actual discussions that took place and what they said, I am not quite sure it would be appropriate for us to basically reflect as to the position of either a Science Advisor or Assistant Secretary capable there as to it. Dr. Decker or Mr. Bradley may tell you the general tenor of what we found during the course of these conversations and the interest level.

Dr. Decker.

Dr. **DECKER**. As Mr. Salgado indicated, I led a team to Japan and also to Canada to speak with them about their interest in SSC. These visits that we made were just to open discussions with these countries on a formal basis, although there had been informal discussions over some period of time.

Miss **SCHNEIDER**. Right. I am aware of who you met with, but I am wondering what kind of commitments you got from each of those because I think that much of the decision-making on this Committee will be contingent upon whether or not we see additional funds because we are, I think, very much in the decision-making process at this point in a chicken and egg situation because I know that there are many members that are not at all enthused about, number one, the big price tag when you compare it to some of the other research needs, but number two, will this continue to drain from research for years on end, and what kind of commitment of support are we getting?

I just might mention that I happened to be leafing through the Department of Energy's news clips here and became horrified when I came upon the $9 billion bail-out for the nuclear industry in the *Washington Post*. There was just an article the other day where here we are once again bailing out, it says here, the size larger than Chrysler, five times larger than how we bailed out Chrysler.

Many of us are very concerned about what kind of bail-out we might be involved in with the SSC.

Mr. SALGADO. With all due respect, number one, that article was written on the uranium enrichment issue.

Miss SCHNEIDER. It has to do with the Department of Energy's decision-making process, however, you must admit.

Mr. SALGADO. It has to do with an accounting process over the last 20 years of how imputed interest was attachment to the uranium enrichment process of a $1 billion commitment by the Department 20 years ago. That is correct, it does have to do with that, but that was a commitment of $1.2 billion 20 years ago in uranium enrichment and whether or not imputed interest is a proper form in debt. There have been numerous discussions on the Hill, not with you, Congresswoman, but with various other people as to a determination as to the appropriate amount. There are experts who say it is as low as $300,000.00, and there are some that say it is $9 billion. I agree with that.

I think the point—back to the point of this hearing—essentially is that commitments, we have no international commitments because we are not committed as a government to go forward either. They have come back to us and said you haven't funded construction, and how can they move it through their political process, through their budgetary process when you as a government have not committed to go forward either.

Miss SCHNEIDER. That is exactly what I meant when I said—

The CHAIRMAN. Will the gentlelady yield on that point?

Miss SCHNEIDER. I would like to complete my thought. That is the point that I was making, that it is a chicken and egg situation, but the point is that the Department of Energy does have in place or it seems historically you have had a decision-making process that fails to look into the future and then puts the pressure on the Members of Congress to bail out different programs. Unless we can see some long lead time process—I am not asking for anything but your process. As a matter of fact, it seems to me that what might be appropriate would be to approach a number of different countries in a conference, host an international conference to see if you can, in fact, get some commitments. But I think that for you to say, well, there is interest, I don't think that is enough to motivate this committee to move ahead on that basis.

Mr. Chairman, I yield to you.

The CHAIRMAN. I think the point we have to make we are trying to get at, and I think the gentlelady is coming very close to something that is in my mind. One is the fact that we are reading that 40 percent of the cost would be generated from foreign investment, is 50 percent, "blah, blah, blah, blah, blah." When you ask anybody for any hard figures, they say, "Well, we talked to this one and we talked to that one, we talked to Rubbia." That doesn't mean anything to us, and you know that as well as we do.

On the other hand, as we try to unravel this situation, suppose the Committee was to consider that we would work on an authorization where we would say to DOE: "Yes, we have enough votes along here, we will send it out to the Floor, we have enough votes to be able to do this, and what we will do is we will commit to half the program." You said 40 or 50 percent, and you want us to get the chicken and egg off the deck, which is reasonable.

We come up and we are going to commit to this, we are going to deem it to be an international program, we will provide 50 percent of the money and invite other countries to come in on the authorization for the other 50 percent. Then we would have shown that we moved, we would have put up preliminary funding, and would that be such a bad idea?

Mr. SALGADO. I am not sure of the exact percentages, but I believe the President's out-year funding already reflects those type of contributions in the out years, Mr. Chairman.

The CHAIRMAN. No, that is not it.

Mr. SALGADO. I understand that, but I mean—

The CHAIRMAN. You know, there are two forms of government around here; one is the representative government. We are the guys that have to vote on it regardless of what you guys think, one way or the other.

Mr. SALGADO. I am sorry, sir. The only point I was making is that I believe—and I don't know what the percentage is—I believe that we have already put that—

The CHAIRMAN. I am not even talking about the out-years, if the gentleman would yield, if the lady would yield further. You know, we make this too complicated for the American people to understand. The issue before us is can we get 40 to 50 percent other funding coming internationally. The question you pose to us, and with legitimacy, is the question of the chicken and the egg: If we don't move, you don't move; if we don't move, you don't move.

We have these reports coming out. I am simply coming back and if this Committee were to entertain what the gentle- lady is thinking and we were to come back and say we will authorize the project, we will put it to a vote on the Floor of the House, we will provide in the authorization legislation this program can go ahead provided we get the other 40 or 50 percent, whatever the figure may be, we will provide some money, however, to go with the research work that has to be done on the magnets and so forth and see what happens.

Now we would have moved. We would have committed ourselves to it but now we are saying it should have with it some international cooperation. Does that sound reasonable?

Mr. SALGADO. It sounds reasonable. I don't know what the implications are in the international community, but it obviously sounds reasonable. The problem that I have is I can't guarantee you 47, 46 percent.

The CHAIRMAN. I understand that.

Mr. SALGADO. But I understand the point.

Mr. Chairman, if I could have one—

The CHAIRMAN. Well, it is the gentlelady's time. Go ahead. She will let you go.

Mr. SALGADO. I would only ask that I be able to submit for the record, at least—not leaving the *Post* as the ultimate authority on the $9 billion mismanagement by DOE, I would like to submit something for the record on that whole issue, though it is not germane to this committee hearing.

Miss SCHNEIDER. Well, it is not germane insofar as the specifics are concerned, but the only reason that I raised it is because I am concerned about future bail-outs of the SSC given the fact that we are here asking for tangible commitments and you are not providing them to us.

Mr. SALGADO. Can't provide them.

Miss SCHNEIDER. All right, but I think that is important to put on the record because if this Committee does, in fact, commit themselves to bear all the costs while we are not necessarily keeping all of the benefits, I think that should be made known to the American public.

I appreciate the Chairman saying what I was thinking before, but now I would like to add a little further what I think the American people will be thinking. I think we have to acknowledge that once major breakthroughs are achieved, it is very difficult to prevent other countries from adopting these new discoveries to their own industries. Additionally, I think a joint international SSC venture would strengthen our relationship with our allies by allowing us to work more closely with them on this project and have it be toward our mutual benefit.

Quite frankly, that, in essence, is the message that I sent in a letter to the President with the signature of many Members of this Committee, but there is the concern on the part of the American people that we fund the research and then our allies pick it up and take it on through the innovation process from there. I think that we will provide greater security for that information garnered by having it be a well-established international effort.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentlelady.

The gentleman from Iowa, Mr. Nagle.

Mr. NAGLE. He already gave away my best line. I am from Iowa and we didn't apply as a site, so I think you did an understanding job, with the exception that your list fails to include the non-applicant States best qualified.

What was originally appropriated for the site selection process? How much money was originally appropriated?

Mr. SALGADO. Sir, there was none targeted for the site selection. The line basically was on an R&D line within that frame of the $25 million, and then the $10 million for construction, so there was not a line appropriated for the site selection process.

Mr. NAGLE. So $25 million for site selection and then another $10 million for—

Mr. SALGADO. Construction. Was requested. Only $25 million was appropriated.

Mr. NAGLE. And then I see where we had a little problem with the amount that it actually took for site selection, did we not?

Mr. SALGADO. We are currently in the middle of site selection, yes, and the amount is increasing, or is more than we anticipated, I guess is the best way to put it.

Mr. NAGLE. How much more?

Mr. SALGADO. Jim, I would ask you. I don't have a ballpark figure.

Dr. DECKER. I would say it was probably $5 million or so more than we figured, $4 or $5 million.

Mr. NAGLE. So $8 million?

Mr. SALGADO. No. We anticipated that the total cost would be that, but above and beyond. I think our anticipation was, and Jim can correct me if I'm wrong, or Dr. Decker can, that it would be 2 to 3 million dollars, and we are about $4 to $5 million over what we anticipated now, sir.

Mr. NAGLE. So on a $25 million budget, we ran roughly 20 percent over?

Mr. SALGADO. The problem was that we did not anticipate the cost factors, number one, of the site selection process, and I will be very candid that it was an oversight on our part to put appropriate funds in there for the site selection process, taking the ongoing R&D activity at the same time as the site selection process. It was our mistake.

Mr. NAGLE. Why did that happen?

Mr. SALGADO. It was a screw-up, to be perfectly honest.

Mr. NAGLE. Tell me about it. What kind of a screw- up?

Mr. SALGADO. It never came to be an issue until all of a sudden when approximately, I gather, a month or two ago we found out that the cost factors in the site selection process were $5 million over, and the negative impact on the $25 million was fully realized, and then we anticipated to go forward with a reprogramming from Management and Administration. The money is there. We had indications, I believe, at the staff levels that there wouldn't be a problem with it, and then it was denied.

So essentially, it didn't surface. It was not a conscious decision not to put it in. Somebody didn't think about it at the right time and the right place, and what developed then, of course, is the $25 million, and then the site selection process itself increased to $4 or $5 million.

The CHAIRMAN. Will the gentleman yield?

Mr. NAGLE. Certainly, Mr. Chairman.

The CHAIRMAN. Just for clarity. If the gentleman will yield, what is confusing me a little bit is we allocated $25 million for the site selection process. That is the point we have got to clarify.

Mr. SALGADO. No, sir, we did not.

The CHAIRMAN. What did we use the $25 million for? That is what the gentleman is asking you.

Mr. SALGADO. No. The $25 million is for the continued research and development, so that $25 million was for the research and development. Within that $25 million, the Department anticipated, rightly so, to use $2 or $3 million for the site selection process. The cost factors of that site selection process should have been anticipated by myself, should have been anticipated by the Department. They were not, and what happened is we ran $3 to $4 million dollars over that.

The CHAIRMAN. But it was $3 or $4 million dollars not above the $25 million, what you had allocated internally for what you believed the site selection cost to be. Are we misunderstanding you?

Mr. SALGADO. I am sorry. I didn't follow that.

The CHAIRMAN. What did you do with the $25 million? You didn't spend it for site selection. That is what he is asking you.

Mr. SALGADO. No, sir. That is continuing. That is the research and development activity on the magnets that is continuing there. That $25 million is also being utilized for the research and development on the magnets that are continually going on in three laboratories.

The CHAIRMAN. If the gentleman would yield further, what proportionate share of the $25 million has been allocated or spent for site selection as of now? That is what I'm asking.

Mr. SALGADO. I would ask Dr. Decker to respond.

Dr. DECKER. I don't remember the exact number, but I think—

The CHAIRMAN. Was it $3 million, $3.5 million, something like that?

Dr. DECKER. I think it is around $3 million.

The CHAIRMAN. About $3 million.

Dr. DECKER. About $3 million.

The CHAIRMAN. If the gentleman would yield further, has all of the $25 million, including the $3 million, been expended now or committed?

Dr. DECKER. No.

The CHAIRMAN. So you still have some of the $25 million?

Dr. DECKER. We still have some, yes.

The CHAIRMAN. How much do you have left?

Dr. DECKER. Through the end of March we will have spent about—I don't have an exact figure, again, but I would guess it is going to be around $18 million.

The CHAIRMAN. In toto out of the $25 million?

Dr. DECKER. Yes.

The CHAIRMAN. The gentleman from Iowa.

Mr. NAGLE. Just so we can crystalize this. Initially we anticipated spending approximately how much on site selection?

Dr. DECKER. We thought it would be around a couple million dollars.

Mr. NAGLE. And it turned out to be how much?

Dr. DECKER. It is turning out to be $8 million.

Mr. NAGLE. Could you tell the member from Iowa, new to the committee, why that should give me confidence in the future projections for the Super Collider?

Dr. DECKER. I think the difficulty that we ran into was exactly what we had to do under the NEPA process in terms of the alternatives that have to be addressed. What we did not anticipate at the time was having to do essentially a full Environmental Impact Statement on all the BQL sites.

Mr. NAGLE. Now, if you only need $5 million more, why did we as a Committee receive a request from the Department to reprogram funds from Management and Administration accounts amounting to $8 million for costs in order to provide for funds for costs related to the site selection process? Where does the extra $3 million go?

Dr. DECKER. The magnet R&D program.

Mr. NAGLE. Is there a problem in that program, too, in terms of cost?

Dr. DECKER. No, I don't think that there is a problem in term of costs.

Mr. NAGLE. Well, why do you need $3 million more?

Dr. DECKER. To try to keep our magnet R&D essentially cn schedule.

Mr. NAGLE. If you don't get the money, it slips from schedule?

Dr. DECKER. We could get a little bit of slippage, yes.

The CHAIRMAN. Would the gentleman yield again, please?

Mr. Nagle. Sure.

The Chairman. At that particular point and following his line of discussion, what do you need to complete the site evaluation of the seven sites? We discussed, and I remember the question indelibly here, and we brought up the point of view of the Environmental Impact Statements, was there enough funding there, and the answer came back—because we were trying to give you more money at the time—and the answer that came back said that what the States were going to be doing, they would be providing enough information as to what the ground conditions were and test borings and environmental data.

We asked that question. I asked it myself. I remember it specifically. Now we are coming back and we are saying that in order for a next decision to be made of the seven sites that we have, you have got to do an Environmental Impact Statement, regardless of what is involved, on every one of them. Is that fair commentary?

Dr. Decker. Yes. I think under the NEPA process that one has to address alternatives to your preferred site.

The Chairman. Of course. If you have a 404 permit involved, there are a thousand points involved in this, and I don't know how you are going to do it in two months time anyway. But however, have you started those Environmental Impact Statements yet?

Dr. Decker. I guess we are at the point of collecting some material on it, yes.

The Chairman. If the gentleman would yield further, is your plan to have the DOE do the Environmental Impact Statement internally? Are you going to hire somebody else to do it?

Dr. Decker. We have a contractor.

The Chairman. You have a contract out. So he must have some feeling. They must be able to tell us how long it will take. They know what the criteria are under NEPA, and we must have some idea what the costs are. Is that reasonable?

Dr. Decker. Yes.

The Chairman. All right. Query. That is the question I think he is asking. We are asked to try to support you, and we have turned this piece of paper back 50 times. There are negotiations going on to try to help. The question before the House, I would say, at the moment is you have said you spent $16 million, was it, or $18 million. That gives you $7 million left to do something with. They are telling us that if we don't sign and get the Appropriations Committees to go along, that you will have to start laying off some of your expertise, the trained people, blah, blah, blah.

In addition to that $7 million you have left, how much is it going to cost to do the Environmental Impact Statements on the seven sites above and beyond what we are doing in salaries for research personnel? Do you know?

Dr. Decker. In this fiscal year or total?

The Chairman. Well, if you are going to make the award in November, somebody better finish it in this fiscal year, or between, carrying it over to November. Correction.

Dr. Decker. The final site decision is in January. That is when the Environmental Impact Statements have to be finished. So some of that spills over into fiscal year 1989.

The CHAIRMAN. Okay. How much do you need? How much do you need to complete the Environmental Impact Statements?

Dr. DECKER. From where we are now?

The CHAIRMAN. Yes, sir.

Dr. DECKER. I believe it is about $5 million.

Mr. NAGLE. If the Chairman would yield, $5 million in addition to the $8 million reprogrammed?

Dr. DECKER. No.

Mr. NAGLE. I feel like I am negotiating with my son about his allowance.

[Laughter.]

Mr. NAGLE. I am sorry it is so confusing.

Mr. SALGADO. There is a question, I believe.

Dr. DECKER. I am sorry.

Mr. NAGLE. I interrupted the Chairman, and I yield my time back.

The CHAIRMAN. You said to us that you have, of the $25 million, you have committed $18 million and you have $7 million left.

Dr. DECKER. Yes.

The CHAIRMAN. And you did bring up a good point that it is between a 1988 and a 1989 appropriation.

Now the next question that we are both asking. We know that we have to do the Environmental Impact Statements. That is a given. And I would assume we are going to do that on each site. Is that correct?

Dr. DECKER. That is correct.

The CHAIRMAN. So therefore, if we are playing with a level playing field then everybody is going to have a fair chance of the seven states that are left without saying we will just make an assessment here, but however, that the Committee would find most repulsive indeed. So now we are coming back and saying that between 1988 and 1989, how much is it going to take to finish the Environmental Impact Statements, of which you have now spent $3 million on site selections and so forth? Is it $5 million?

Dr. DECKER. It is $5 million, yes, sir.

The CHAIRMAN. All right.

Mr. NAGLE. Now that money, that $25 million that you want to transfer the $8 million out of, what is the impact of—

The CHAIRMAN. No.

Mr. NAGLE. It was $25 million originally, and you want to reprogram $8 million of it? Have I got that right or wrong?

Mr. SALGADO. No. The $8 million would come from our Management and Administration account of unobligated balances that are currently—

The CHAIRMAN. Eight million dollars additional.

Mr. SALGADO. Additional to that $25 million, sir.

Mr. NAGLE. I know I shouldn't ask this question, but how much money do you have in this—

Mr. SALGADO. Unobligated balances?

Mr. NAGLE. Unobligated balances. Thank you.

Mr. SALGADO. Unobligated balances? I don't know, sir. I can submit it for the record if you so desire.

Mr. NAGLE. Is it $50 million, $100 million, $200 million?

Mr. SALGADO. No. I wish there were. No, sir.

Mr. NAGLE. Now, there is some concern on the Committee that the transfers of the reprogramming fund will have some impact on your magnetic—I believe it is called dipole magnetic development, and that some of your contractors will have to start laying people off. Now, how do you propose to get out of that bind?

Mr. SALGADO. That is the difficult position we are in. You have to remember that if, in fact, there is a denial across the board to reprogram the funds for the site selection process, we now have a limited amount of money, the $25 million less what has been expended at this particular time, to carry out two or three missions: number one, continue the site selection process; number two, continue the R&D activity. There have to be some trade-offs made in there if, in fact, we are not allowed to reprogram any funds.

One of the trade-offs, of course, is as Dr. Decker said, the EIS process can be slid out and therefore incur those funds into the 1989 budget rather than the 1988 budget process.

The CHAIRMAN. Assuming you get an allocation for the SSC.

Mr. SALGADO. Of course, sir. Of course. Or if, in fact, there is continued R&D activity rather than construction activity. The one point I would like to make that has been raised in private hearings is this is not any effort to somehow develop construction monies, as you are well aware, Mr. Chairman. It is merely to carry out the R&D activity and the site selection process.

So there are trade-offs and options. Yes, it is right that you could lay off people and slow down some of the R&D activity in the magnet development and continue on course and time on the environmental impact and the selection process. There is a trade-off to be made to slide some of the Environmental Impact Statements, incur those costs, if allowed, into the 1989 budget timeframe and maintain the R&D activity at that level.

Mr. NAGLE. What do you recommend to the committee?

Mr. SALGADO. We are recommending to the Committee that the Committee support us in attempting to reprogram $8 million from unobligated balances so that essentially the R&D activity maintains its course and that the Environmental Impact Statements, both in the 1988 and 1989 time frame, can be done appropriately since there has been time and money invested by the states in those.

Mr. NAGLE. And what is your understanding of why you were turned down by the Appropriations Committee of both the House and Senate? Apparently they didn't like this idea.

Mr. SALGADO. I am not quite sure. We did get a letter rejecting it. We are continuing to have dialogue. The Secretary is meeting with various Members of both the Senate and the House to pursue this issue, and hopefully the decision is not closed. I only say hopefully, but we are pursuing this. I don't have the rationale, sir. There are letters we could submit to the record that were sent out, but it essentially was a denial of the request.

Mr. NAGLE. And if we don't make the appropriation for the transfer, how do you propose to meet the program goals for fiscal year 1988 in the dipole magnet program if we don't do what you are suggesting that we do?

Mr. SALGADO. Again, one of the ways would be to slide the EIS, the Environmental Impact Statement that would be, costs incurred in the 1988 budget, to slide those into the 1989 budget with hope that we would be appropriated funds to utilize to complete that process. So there are options to generate or there is the option of slowing down the magnet development also. None of those are pleasant options, but those are the options that are available dealing with that limited world of $25 million.

Mr. NAGLE. Thank you, Mr. Chairman.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Mr. Salgado, why is DOE so insistent that everyone reviewing the SSC must beware of Canadians bearing gifts?

Mr. SALGADO. I am not sure that everyone is, sir.

Mr. BOEHLERT. Well, DOE is. That is your line.

Mr. SALGADO. Bearing gifts?

Mr. BOEHLERT. Well, I am sure you are familiar with the proposal that was submitted, unsolicited to the Department of Energy proposing a transboundary site. Would you tell us what the Department did with that proposal?

Mr. SALGADO. The Department rejected that proposal.

Mr. BOEHLERT. Did it even review it?

Mr. SALGADO. No, sir. It reviewed it to the extent that it failed to meet one of the established criteria, which was that it had to be located within the Continental United States. Once it failed to meet that prima facie criteria, it was rejected, sir.

Mr. BOEHLERT. Can you tell me the reasoning supporting that criterion that it had to be solely within the Continental United States at the very time the President and the Prime Minister were negotiating the biggest free trade agreement in the history of our two nations? At a time when we are preparing to go to the Shamrock Summit IV where we are enjoying friendly relations with our neighbors?

Mr. SALGADO. Believe me, there is nothing derogatory nor is it a question that the Department of Energy distrusts Canada. I think it was felt it would be in the best interest of the project, number one, from a management standpoint that one government and one agency, i.e., the United States Government, was able to run this project through the collaboration and cooperation of foreign interests that would like to participate. I think there was a management side of it.

I think the other issue was the fact of the matter is, as I recollect, that there was input from some gentlemen and gentleladies on the Hill that felt that it was important that if the project was to go forward, that it be located in the Continental United States.

Maybe Dr. Decker has some additional background that I don't have.

Mr. BOEHLERT. But can you give me the reasoning behind that? I am trying to find out the reasoning. You come up with a lot of criteria, but I would assume you can back up with sound reasoning.

Mr. SALGADO. I think that the most cogent, practical reason that I would have, which I believe I alluded to and I probably wasn't clear, was the fact of the matter is that if you are basically building a Superconducting Super Collider basically having two countries having a vested interest on it, their own facilities and their own activities, it seems to me that unless we are going to establish international cooperative agreements, that the management and direction of that would be very difficult to do. We felt in the Department that if, in fact, the Nation felt it was important to go forward with this, that it was a project of the United States itself, it should be located within the Continental United States. That may not be a satisfactory reason, sir, but I believe that those were the underlying rationales of why that was put in the criteria.

Mr. BOEHLERT. It is very shallow reasoning, quite frankly, and I think a number of my colleagues on the Committee share that view. Following up on what Miss Schneider said a little bit earlier, you can expect from me because I have already advised the Chairman that I fully anticipate when this authorization comes to the Floor to have a specific requirement for international participation in this project.

I am sure you are aware of the fact that the CERN project is a transborder project. That seems to be working quite well. What incentive is there for any other country to participate in the construction cost?

Mr. SALGADO. Their incentive is to participate in the results that their high energy physicists have a place to come to do their experiments. The fact of the matter is that there is no place else such as this project built in the world where these types of experiments at that type of energy levels can be conducted, and I think that if that is built, they will be here.

Mr. BOEHLERT. We know they are going to share in the advantages or the benefits of it; I would like them to share in the burden a little bit.

Mr. SALGADO. So would we. And I think part of the benefits have to go with part of the burden, and that is part of the concept behind international collaboration and cooperation in this.

Mr. BOEHLERT. I believe Dr. Decker said to our Subcommittee on International Scientific Cooperation last week that a number of the countries that he contacted indicated they would like to participate in the planning for this project. Is that correct, or am I misinterpreting what you said?

Dr. DECKER. We invited scientists from other countries to participate in the design work that has gone on to date, and a number of countries have sent their people and who have worked with us.

Mr. BOEHLERT. Mr. Salgado, do you get sort of the feeling that this is sort of slipping away? I never used to know what "dead on arrival" meant in this town, but I can tell you right now that this authorization will be dead on arrival on the Floor if we do not have some firm commitments in hand for international cooperation. It seems to me, despite my repeated attempts to get something specific from DOE, we are not getting anything. We are getting stonewalled. I mean we are getting a travelogue and Dr. Decker was very kind to share with the subcommittee all the places that he visited, and I am sure that was a difficult assignment, but I would like to know something specific.

What is coming out of these visits?

Mr. SALGADO. I understand your concern, and we agree that international collaboration and cooperation and contribution is important, but if I came before this Committee and I asked this Committee to appropriate $100 million so that we could go to CERN or we could go to Japan because they have a proposal on the table that they are thinking about funding this, I would think that probably this Committee and this Chairman and yourself would probably tell me: Let's see a firm commitment on the Japanese, the Swiss, the Italians' part.

Again, I agree with you. It is the chicken or the egg. It is the union card or the job situation. It's a difficult situation to be in and I am not comfortable with it. I understand that. But at the same time, I can understand what those communities are saying to us because they have to go before their body and they have to allocate "x" amount of dollars out. I don't think this Committee would allocate or appropriate $100 million that possibly Italy is going to build a Super Collider in the next two or three years. Somebody has to break out and—I guess the point is that some country has to take a leadership role and a commitment to go forward, and we firmly believe that the United States has that leadership role in the international community now, and that we can maintain it by our commitment to go forward.

I agree with your concern, sir, that international contributions are important to this project.

Mr. BOEHLERT. Last year when the authorizing hearings were under way, I asked someone from the Department why not the transborder site for consideration, and the answer was something to the effect that the Department felt it would give an unfair advantage to one site over other sites. Would you share that view?

Mr. SALGADO. I hadn't thought of it in that context. Probably not. Depending on the size that was developed on the transboundary, merely because we get back into the Chairman's issue on life-cycle costs and the question that in the band that was placed in there, the Department put in, I believe, a 10 percent band, I don't believe that it would. But I really don't have those figures, and I could have somebody respond for the record, sir. But I don't believe it would unless there was such a large portion to be constructed on the other side of the border and therefore the cost factor somehow became diminimus because of that. I don't know. I really just don't have the answer for you, sir.

Mr. BOEHLERT. That is a better answer than your predecessor gave. Your predecessor said to me in response to that question that yes, we do think it would give an unfair advantage to one site. My response was, and the record shows this: How about giving an advantage to the taxpayers who are going to foot the bill for this thing?

You know, the Canadians have said they would pay for 10 percent of the construction cost. The Canadians have low-cost hydropower to offer this project. We are talking about a project that is going to cost 5 to 6 billion dollars. Everybody is scrambling all over this town to find out where we are even going to get $100 million this year, not $363 million, and we summarily rejected, not even considered a very thoughtful preparation of a proposal because it is only for America. We are going to foot the bill, and they are going to have the benefit. You know it as well as I do.

Thank you.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from Illinois, Mr. Bruce.

Mr. **Bruce**. Thank you, Mr. Chairman.

Secretary Salgado, I just wonder. The Chairman asked earlier about States that responded for an invitation for site proposal, that they were told of the criteria for the site selection, you answered in the affirmative. At the time the site selection procedure was put forward, did any State express immediate displeasure of the siting procedure that they had been apprised of?

Mr. **Salgado**. It is my recollection, sir, that there was not any displeasure with the siting criteria. The only issue that came first and foremost to the screen of everyone dealt with the Fermi Laboratory and any potential advantage in the life cycle cost scenario that would befall the State of Illinois given that.

Essentially, like I have indicated before, that proposal had been sent out as early as 1985 when the criteria were being developed to various Governors who may or may not have changed office at the time. But as to what the criteria laid forth, basically the geology, tunneling, the regional resources.

I have no indication there was a problem with those criteria. The main focus was how that criterion was going to be applied to ensure that there was a level playing field and everybody had an equal opportunity.

Mr. **Bruce**. And the only objection or concern expressed at your pre-bid proposal meetings was on the impact of Fermilab and what it might to do Illinois' proposal?

Mr. **Salgado**. I think that that was a continuing issue throughout the entire process until the Domenici amendment had passed as to the life cycle costs and the "advantage"—I should couch it in terms of not just Fermi because there was another State that had Federal assets involved in it, which was Idaho, and there was a concern of how these were going to be factored in and if life-cycle costs would have a dominating factor and there would be an unfair advantage. That was the one continuing thread through the entire process up until the selection.

Mr. **Bruce**. I am just curious. I don't want to pick on Mr. Boehlert's State of New York, but at the time when you required in your request for proposal that any site be totally within the United States, did New York come to that pre-bid meeting and say that they could not meet the criteria and ask for a waiver?

Mr. **Salgado**. I would have to submit that for the record since I didn't go to the pre-submission assembly. I am not quite sure what the record reflects on that, and I would research it and submit it for the record.

Mr. **Boehlert**. If my colleague will yield, we had three sites in New York that met the criteria, and this was not one of them, the transborder side. That wasn't even considered. It was rejected out of hand. It didn't get beyond the clerk.

Mr. **Bruce**. My question, Mr. Boehlert, was whether or not at the time you submitted the proposal, the requirement and request for proposal was that it be all within the United States and they rejected that one proposal. I just wanted to know if New York had raised an objection and sought a waiver, and if they had and it had not been given, that puts it in a different light than not having sought a waiver at all.

Mr. Boehlert. There was no formal submission. It was made abundantly clear by all with whom the New Yorkers talked within DOE that a transborder site would not even be entertained, despite the fact that the Canadians would pay 10 percent of the cost of construction, despite the fact it had low-cost hydropower, despite all the pluses they would bring to the project.

Mr. Bruce. And Secretary Salgado, after the site selection was narrowed down to the current contenders, you had a debriefing process at that point, didn't you, where all the States that had submitted proposals had a chance to come in and were told how you arrived at these seven sites?

Mr. Salgado. Yes, sir. They first of all were notified and the National Academies put out their brochure on the siting of the Superconducting Super Collider. Then each State that did not make the Best Qualified List had a number to contact to arrange for a debrief from the Department of Energy, who had done a validation process, as to this whole process. They had an opportunity to come in, and obviously there were some gentlemen and gentleladies on the Hill that basically requested some private briefings from myself and other members also.

Mr. Bruce. We talked about the immediate response, but during that debriefing period, did you receive complaints about how the DOE had handled the siting proposals at that point?

Mr. Salgado. Yes, sir, I did.

Mr. Bruce. And can you summarize the general complaints that you received?

Mr. Salgado. I think one of the major discriminating factors happened to be the second criteria of regional resources. There was a great concern from some of the States that essentially too much weight was placed on regional resources and some of the subcriteria and that the criteria itself became biased and prejudiced against certain States not having high density urban areas and more of a rural setting.

I think that is probably a fair analysis, that the two major discriminators were geology and the regional resources.

Mr. Bruce. And Mr. Lujan asked questions earlier that I heard about it being more than 20 miles from a major metropolitan area. Would that be a typical objection or complaint that you had heard?

Mr. Salgado. I think regional resources in the whole generic sense. I think one of the areas that probably I heard the most concern dealt with probably the—how do I phrase it—maybe the quality of life and the availability of employment for spouses and things like that. That was one of the ones that really basically was a high point for many, many members of both the Hill and the Senate.

Mr. Bruce. You had a chance to respond to these complaints. Were most States satisfied with your explanation of what had happened and how you had gotten to your point of decision on the States you had selected?

Mr. Salgado. No. I believe that the GAO investigation is looking into this matter at the same time. I can't say that they were satisfied. I think that there were a lot of States that felt that they submitted very sound, good proposals. Again, it is a question of not that they were bad proposals or bad sites, but there were better sites and better proposals.

There were many States that had put in a lot of time, effort, dollars and sense and expended a lot of energy, and I don't think that they were happy or satisfied. I think they understand the process, and I think that I would hope that after a close analysis and reflection, they would believe that this process, though they may dislike the criteria, that it was handled in a fair manner with certain integrity and credibility not only by the Academies but by ourselves. But I can't say that they were satisfied, no.

Mr. BRUCE. But you did respond to their questions and explain why the Department reached the decisions they had reached.

Mr. SALGADO. We tried to respond to the specific issues that they raised as well as their concerns, that is correct.

Mr. BRUCE. The Committee here has also in a couple instances today brought the question of international cooperation. What would be the impact right now of not receiving funding in fiscal year 1989 for the SSC, the impact on the European community, and what would happen with the Canadians and the Japanese?

Mr. SALGADO. It is my opinion and strictly my opinion, sir, that I think we are at a decision point on this process, and obviously the international community awaits what we do. I think there are plans afoot for increased activity both at CERN and in other areas. I think that if, in fact, we decide not to go forward with this project, then I think the international community will be coming to us and asking us to contribute dollars, cents, time, effort and money to their projects because obviously this collider is going to be built. I think the international community is going to move forward. They have a vested interest to move forward into their areas. They have taken an assertive role in high energy physics, and I think that is something that is a reality.

Mr. BRUCE. The Japanese, the same thing?

Mr. SALGADO. I am not quite sure where the Japanese sit in their development. They are interested in this activity as they are interested in all high tech and cutting edge of basic science research. I think they are going to participate. There is going to be participation.

I think that—and this may sound like heresy, Mr. Chairman and gentlemen—but I think that if we decided not to go forward, I think that in two or three years somebody, who ever sits as undersecretary, is going to come before this Committee and you are going to ask, and we are going to say that we should put some money into this new Super Collider, wherever it is going to be built. I think we have scientists and we have people that are going to have to be able to pursue this, and they are going to be going to it.

We have a vested interest to participate in a Super Collider, this country does, and I think it is something that we have to realize. If we don't build it here it may cost us less, but we are going to go and participate someplace. I think it is in the interest of the country and in the interest of science to do it.

The CHAIRMAN. If the gentleman would yield, let me build on that. I guess we have come full cycle now and we want to get these other folks in because they have other meetings they have to go to. Let me suggest the following.

I think that, number one, to our knowledge there is not any country or group of countries that are talking about building a super collider the size and magnitude of the one that we are projecting here. Is that a correct fact?

Mr. SALGADO. I think the Russians have a linear, I believe, but I am not quite sure—

The CHAIRMAN. No, I am talking about this type of operation. There is nobody that is doing anything, including CERN.

Mr. SALGADO. I would ask—

Dr. DECKER. Not at this energy and this time.

The CHAIRMAN. Not at this energy level at this point.

Dr. DECKER. That is correct.

The CHAIRMAN. Now, the question the gentleman from Illinois is asking, which is the burning question before us, is, one, we talked about the funding that may be needed for the $8 million and what would be needed to carry on the Environmental Impact Statements and so forth. As far as I am concerned, you are not going to build anything unless you do that anyway. That is a matter of law.

The second point one comes back to and says is well, I can see where the Appropriations Committees are saying, "Let's take another look at this $8 million because if we give the $8 million, is that tantamount to saying we are ready to go ahead with this project, regardless of having to lay people off?"

The third thing one comes back and says is, "Well, okay, we fought like mad to get the $1.65 billion allocated to budget function 250. Out of that budget function 250, the $1.65 billion will go down to $1.25 billion, if we can pass that resolution and the Senate holds up, for NASA alone. Then the balance, perhaps, at the most would be $100 million allocated to DOE R&D at this particular point unless there is some miracle occurs." And we are all looking for a miracle.

Now the question. Or let me make one more comment to you. I made a speech the other night and I made the following observations. There is no way we can do the NASA space program without an additional $3 billion. It can't be done. We are going to be limping along, limping along, and we will never catch up at the rate we are going. So we have got to look for new funding mechanisms. We are talking about a possible space trust fund, for example. That is not such a crazy idea. And two or three other generic ideas to help raise outside funding and industrial funding and business funding and so forth and so on.

Having said that and agreeing with what you are saying, here we find ourselves in the dilemma of a factual before us, and we are saying that they have asked for $360 million, I believe it was, and your R&D program conducted at the enhanced level would be $64 million of the $363 million, as I understand it. The $64 million is needed to do the research, continue on with the research work that has to be done on the magnets and everything else involved. Is that a fair commentary?

Dr. DECKER. That is correct.

The CHAIRMAN. So you need at least $64 million to keep this program alive from a technical point of view, plus the $8 million to be able to do the Environmental Impact Statements and everything else, at the very bare bones minimum. Have you looked to an alternate proposal? The assumption that you are going to get the $363 million is indeed pie in the sky at this point. The question is what does the Committee do, what does the Administration do, what does the Congress do to, first of all, say, "Yes, we are interested in this program, all of this bit on the international end we understand, but what do we do to keep this alive, and how much money do you need to do that?" Have you got a contingency plan?

If you have, don't tell me, I don't want to know, but you better be thinking about it right now. Do you understand where I am trying to come from?

Dr. DECKER. Yes, sir.

Mr. SALGADO. Yes, sir.

The CHAIRMAN. We have got to have some kind of feeling from the Administration as to what you are going to do. They are going to vote on that resolution that is going to put $1.65 billion into Function 250, period. It is that simple, depending upon what the Senate may or may not do.

Let me ask this question. How do you carry the program out? What do you do now? Suppose we support you in toto. Suppose we devise language that is going to look to the international language that has been talked about today. Suppose we come back and we continue to fight to provide the funding, and suppose you got $100 million. What would you do? Where would that put you at that point?

Mr. SALGADO. If we got $100 million and had authorization, appropriation to go forward with construction, it would put us in the position.

The CHAIRMAN. Wait a minute. Une moment, s'il vous plait. You are going to go ahead with the construction. We are talking about $64 million. What would you construct?

Mr. SALGADO. There are some long-lead items that we could move forward with basically to at least get it moving because the essence would be that what we would have to do at that particular time is we would first of all have to present to you and to lay out the entire game plan or the methodology for basically the completion of this project because it is obviously going to be elongated from a $363 million to a $100 million.

The second point, of course, is, having overcome the chicken or the egg syndrome that we referred to here, we could move out aggressively in the international community soliciting those funds and dollars and cents to move forward so that we could move forward in the construction of this whole process. That is what we would do.

Mr. NAGLE. Will the gentleman yield?

The CHAIRMAN. Of course.

Mr. NAGLE. I think the Chairman is on the track, but I would like to take the track further than that, if I may, with regard to the testimony that you have submitted to us here today. You talked about excluding funding for the SSC. There is still a projected increase in DOE's other basic science research activities of over 34 percent, average annual increase of over 7 percent; same period budget for National Science Foundation increased by almost 76 percent; budget for National Aeronautics and Space Administration to increase by 67 percent.

My first question to you is are not all of those increases, including the increase for the SSC, based on the President's budget assumption?

Mr. SALGADO. Yes, sir.

Mr. NAGLE. And that includes the elimination of programs that Congress has traditionally refused to eliminate.

Mr. SALGADO. That is correct, sir.

Mr. NAGLE. Could I amend the chairman's request for your plan for $100 million to could we see a plan that would include the funding at the more traditional levels Congress has done? I think that is more realistic.

Mr. SALGADO. I am afraid I don't understand as to – the traditional levels for high energy physics?

Mr. NAGLE. For example, we don't abolish mass transit. We don't abolish CSPA. Just picking two out. So given this testimony and projection is based on what if we did what the president wants us to do, which we have never done before, doesn't let either one of us plan very realistically, does it?

Mr. SALGADO. No, but I think there has to be a starting point upon which either priorities are to be made, and the President has submitted his priorities and his budget to the Hill for a whole series of discussions and dialogues that are taking place, and that is the process that we are involved in. I agree with the point you are making that the fact of the matter is there is only so much water in the wall, and if you are going to prioritize "x" amount, that means less for some other areas. I understand that.

The problem I am telling you is that in the proposed budget, the President's emphasis has been on science, technology, research and development. There are some cuts that take place in it that you and I may disagree about. I understand that. But that is the projected and that is the increase of the President's budget alone.

I don't know how I could accomplish your request except to try to go back and take an inflation figure from—

The CHAIRMAN. Except for the point of view, what he is asking you is the fact that we had a fight with your Department last year when we wanted to give you the other $10 million, and they insisted that it carried the word "construction" with it, and the Congress was not about to put any money into construction.

Maybe that is a play on words, but that is precisely what happened. Now one comes back and says we want to make an $8 million because we need that not for construction, we need that now to keep the program alive.

What we are asking you, regardless of what the projections have been—it doesn't matter. The Budget Committee has already spoken. The Congress has yet to vote on it. They have come back and said they are going to allocate $1.65 billion to Function 250, of which they are going to have $1.25 billion going into space, and $100 million may be available to DOE research, all of your research.

Then you are going to have to make some decisions. If we go ahead and we put authorizing legislation through and we work with the Appropriations Committee, how much can we give you for this purpose? Suppose we provided $100 million for DOE? Suppose we could make that stick? How much of the $100 million, of all your other programs, would you allocate for this program?

Mr. SALGADO. Well, it depends on what the cuts are in the other additional programs to see, and I don't have those figures in front of me, so I told know.

The CHAIRMAN. But you're saying for—that's who I want to get on the record—you are saying that you need a bare bones minimum $64 million to keep your research going at the proper level. Is that the correct understanding?

Mr. SALGADO. Yes, that's what our R&D number—

The CHAIRMAN. That's exactly—

Dr. DECKER. That's correct. That's our R&D number and that's the proposal that—

The CHAIRMAN. That is precisely the point I am making. So therefore in order—if Congress were to provide anywhere up to $64 million, that money would have to be allocated for the research work that has to be done on the magnets, etc. Is that a correct statement to make?

Dr. DECKER. Yes.

The CHAIRMAN. All right. If that's so, we're saying that the program can't really even do much with—suppose it is cut lesser than $64 million. Suppose it's $32 million. What happens then?

Dr. DECKER. The development will slip.

The CHAIRMAN. You'll have to lay off people. It's no different than transferring the $8 million, is it, basically?

Dr. DECKER. I don't know if we'd have to lay off people, but obviously the development program slips.

The CHAIRMAN. Let me ask you this question, because I think we are now getting down to brass tacks. If we were not to provide you the $64 million, but some proportionate share having nothing to do with construction, what would that do as far as the time frame of this program is concerned—from an engineering, technical point, I am talking about.

Dr. DECKER. Yes, I understand. I don't know. It is something we would have to examine. I mean I would imagine we are slipping the project by a year.

The CHAIRMAN. At least.

Dr. DECKER. Yes.

The CHAIRMAN. And that has nothing to do with the States in the point of view of the final selection and nothing could move at all on that basis, basically?

Dr. DECKER. I think the construction would have to slip a year.

The CHAIRMAN. All right. So we are not really talking about construction money at that point?

Mr. SALGADO. No, sir.

Dr. DECKER. No.

The CHAIRMAN. Okay. Any further questions?

We want to thank you very much for a substantive presentation. We hope that it has helped to clear the picture a great deal here.

Mr. SALGADO. Thank you, sir.

The CHAIRMAN. So thank you very much.

PANEL 2: NATIONAL ACADEMIES OF SCIENCES AND ENGINEERING

The CHAIRMAN. We now would call for our next panel, who would be Dr. Press, Dr. White, Dr. Kasper, NAS and NAE panel—we call you folks and we appreciate your patience with us. Now, suppose we take Dr. Press first, of National Academy of Sciences. Why don't you go first, Dr. Press?

STATEMENT OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES, WASHINGTON, DC

Dr. PRESS. Mr. Chairman, thank you for the opportunity to discuss the role of the National Academies of Science and Engineering in the site selection process for the Superconducting Super Collider.

I spent many hours in this room over the years, most of them pleasurable, all of them interesting. I am accompanied by Dr. Robert White, President of the National Academy of Engineering and Dr. Raphael Kasper, Executive Director of National Research Council's Commission on Physical Science, who served as staff director for our site selection committee.

Although the Academies exist in part for the purpose of providing advice to the Government, agency requests for assistance and site selection or procurement activities are rare, but they are not unprecedented. In 1965, as has been mentioned here, the AEC asked the National Academy of Sciences to provide its judgment about which of a large number of proposed sites would be best qualified as the location of the 200-BeV accelerator laboratory, now known as Fermilab.

It was no surprise for us then when in 1984 DOE asked the Academies of Sciences and Engineering to assist in the process of selecting a site for the SSC. We agreed to provide such assistance when DOE decided to proceed with the SSC.

Shortly after the President approved construction of an SSC in January of 1987, the DOE formally requested our assistance. We recognized at the outset, of course, the sensitivity of the process in which we were becoming involved, and set out to establish a committee of great expertise and wisdom and one that would have no direct stake in the final decision about the location of the facility.

I believe we assembled a committee that met these criteria: 21 distinguished individuals including specialists in high energy physics, engineering geology, accelerator design, economics procurement, the environment, heavy construction, and large-facility management. The Chairman was Dr. Edward Frieman, currently the director of the Scripps Institution of Oceanography. The committee included two Nobel Prize winners, the directors of several major scientific institutions, the chief of the Army Corps of Engineers, the Secretary of the Smithsonian Institution, the former chief executive officer of DuPont, and the president and two vice presidents of major research universities, among others. Even in an institution that regularly involves eminent members of the science and technology community, this was a particularly distinguished group.

As with all committees at the Academies, this one served without compensation. The members were volunteers, all of whom had full-time positions elsewhere with demanding responsibilities. I should point out that the members of the committee were not chosen to represent or advocate their home States, and they did not do so. I am convinced that they approached their task seriously and fairly.

Before I turn to Dr. Kasper to discuss briefly the process used by the committee in carrying out its charge, I want to make a few remarks about the process from the viewpoint of the president of an institution whose major purpose is to assist the Government in matters where science and technology play a major role.

Any process that chooses among a number of competitors must by its very nature disappoint some of the parties of interest. The extent of that disappointment is probably made even greater in this case because of the very large stakes involved—to science, to local and regional economies, to State and national status and prestige. We knew this when we accepted the very difficult charge placed before us by the Department of Energy. We met that charge by enlisting a group, experienced and dedicated individuals and employing a process that we felt ensured detailed, complete, and equitable consideration of all the proposals received.

Over the past few years, the Academies have developed effective working relationships with State governments, Congressional delegations, and agencies. I am worried that our involvement in this particular process may have strained some of these relationships, and I would regret it if it has. I suppose we could have rejected the request for help from DOE knowing that we would almost inevitably disappoint some of our most valued partners, but we are called upon by our Congressional charter and two Executive Orders to respond when asked, and so we took on the task and did the best, most careful job we could.

Let me ask Dr. Kasper to say a few words about how the committee went about its business and then the three of us will be happy to answer any questions.

[The prepared statement of Dr. Frank Press follows:]

Statement by

Dr. Frank Press

President

National Academy of Sciences

before the

Committee on Science, Space, and Technology
of the
United States House of Representatives

Tuesday, March 22, 1988 - 1:00 pm
Room 2318 Rayburn House Office Building

Mr. Chairman, thank you for the opportunity to discuss with you the role of the National Academies of Science and Engineering in the site selection process for the Superconducting Super Collider. I am accompanied by Dr. Robert M. White, President of the National Academy of Engineering, and Dr. Raphael Kasper, Executive Director of the National Research Council's Commission on Physical Sciences who served as staff director for our site selection committee.

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Now let me ask Dr. Kasper to say a few words about how the committee went about its business, and then the three of us will be happy to answer questions.

STATEMENT OF DR. RAPHAEL G. KASPER, EXECUTIVE DIRECTOR, COMMISSION ON PHYSICAL SCIENCES, MATHMATICS AND RESOURCES, NATIONAL RESEARCH COUNCIL, AND PROJECT DIRECTOR, SUPER COLLIDER SITE EVACUATION COMMITTEE, NATIONAL ACADEMY OF SCIENCES AND NATIONAL ACADEMY OF ENGINEERING, WASHINGTON, DC

Dr. **Kasper**. Thank you, Dr. Press.

Of the 43 proposals that the Department of Energy received in September, 36 were formally sent to the Academies for review. During our evaluation process, one proposal was withdrawn from consideration by the State of New York.

The committee was asked to evaluate the proposals and identify a small number of best qualified sites from among those considered. The committee completed its work in just over three months and prepared a report that explained its process, presented the Best Qualified List, and discussed the characteristics of the sites on the List. I have submitted a copy of the report for the hearing record.

It's worth mentioning some aspects of the charge to the Academies that affected the manner in which the committee went about its business. The Department of Energy asked us to complete the review process in three months. Most of you have seen pictures of the proposals arriving at the Department of Energy in September, and you will recognize that there was an enormous amount of material to be read, digested, and evaluated. The members of the committee devoted a substantial portion of their time to the review process, perhaps more than should realistically expect from a group serving voluntarily with demands of full-time positions continuing unabated during the period. But we met the schedule.

The committee was asked to provide an unranked list of best qualified sites. This was one, perhaps not the most important factor, that precluded the use of detailed numerical schemes in our evaluations. Detailed numerical schemes would have led inevitably to a ranking of the sites.

The committee was to evaluate only information in the proposals and cost estimates that would be provided by the Department of Energy. Additional information, in the form of, say, site visits, was not to influence the decision of the committee. Proposers were made aware of this constraint very early in the process. They were to present all of the information they wished reviewed in the proposals. Now in at least one sense, the lack of site visits made the committee's path easier. If site visits had been part of the process, equity would have demanded that all of the sites be visited and that all members of the committee be involved in all of the visits. Then there would have no way to meet the timetable for the project.

The most significant constraint under which the committee worked, lay in the fact that DOE announced in its Invitation for Site Proposals the six criteria and 19 sub-criteria that would be used in the evaluation process, and the Department also announced the order of importance of the criteria. Again fairness demanded that there be no change in the criteria or their order of importance and the committee faithfully adhered to both.

The Academies were asked by the Department of Energy to treat the proposals as confidential, presumably because the evaluation process was part of an ongoing procurement or procurement-like process. We have tried to be conscientious about the way in which we portrayed the proposals in public. With the exception of the required discussion of characteristics of the sites on the Best Qualified List that appears in the report, we have tried not to make statements about the details of proposals or to characterize strengths and weaknesses of competing proposals. We have discussed with principals involved in some of the individual proposals characteristics of their sites but without providing detailed comparisons with other sites.

Before it received any of the proposals, the committee recognized that it was faced with a task of evaluating proposals using a multiplicity of technical criteria, sub-criteria, and costs. Because of the difficulty, and some on the committee would have said impossibility, of directly comparing the various criteria and the extent to which individual proposals met or didn't meet the criteria, the committee decided against adopting a rigid set of weights that would allow a mechanical means of scoring or grading proposals.

The committee was mindful of the fact that using any other method would highlight subjective elements in the process, but it felt, first, that the process by necessity involved matters of judgment and that it was proper to acknowledge this at the outset; and second, that the use of numbers to grade the criteria introduced only a spurious impression of objectivity and accuracy while entailing every bit as much subjective judgment as any other technique. It was decided then to evaluate the proposals with respect to any given criterion using values good, satisfactory, and questionable.

While the proposers were preparing their proposals, the committee discussed the manner in which it would perform its evaluation. We concluded early in the summer that it would be impossible to expect all 21 members of the committee to gain a detailed comprehension of all aspects of all proposals, so we establish working groups to focus on each of the six major criteria and on costs. Each working group was made up of the members of the committee with particular expertise in its area of focus.

The working groups were asked to identify strengths and weaknesses of all the proposals in their particular area of concern to form a basis for discussion by the full committee and to provide an initial evaluation of the proposals as an input to the deliberations of the full committee.

The report describes how the committee interpreted the criteria announced in the Invitation for Site Proposals, so I won't repeat the discussion here, but I will indicate some noteworthy aspects of the criteria and the proposals.

The most important criterion was "geology" suitability for construction and operation, stability, minimal risks encountered in construction and operation. In general, the proposals were quite good in this area, but although only a handful of the sites presented what appeared to be overwhelming geological problems, there were significant geological distinctions among the sites, and some sites had geological characteristics better suited to the SSC than others.

"Regional resources," the next criterion in order of importance, included a broad range of characteristics of the sites. The committee notes in its report that the components of regional resources are less amenable to detailed technical analysis than are geological conditions. Faced with the questions of identifying just which regional resources were most important to the efficient and effective construction, startup, and operation of a major scientific laboratory, the working group on regional resources convened a meeting with directors and representatives of a number of large scientific laboratories to discuss those aspects of community and regional resources that are in fact most important to the actual operation of their laboratories, as opposed to those that unexamined conventional wisdom might highlight.

There is much experience in the United States with running large scientific facilities and that experience was quite helpful in fashioning the committee's views. Again the Committee explained its conclusions on this matter in the report.

Environmental impacts of construction and operation were considered. The committee concluded that no site proposal presented environmental problems that could not be prevented or minimized, but because the sites proposed displayed such disparate environmental conditions, it's not surprising that there were considerable differences in the impacts that could be expected at the various sites.

The committee sought help from experts in the Corp of Engineers in its examination of the strengths and deficiencies of various plans for timely acquisition of the required land and found considerable differences among the proposals. Some of the plans were quite complicated and involved acquisition of a large number of small plots. Others were simple in comparison.

Regional conditions, natural and man-made conditions that could affect construction and operation of the SSC were also reviewed. Again, there were significant differences among the sites, although the committee concluded that no site was characterized by such negative conditions that it could be eliminated on this basis along.

The last of the technical evaluation criteria was "utilities" and it provided little discrimination among the sites. The committee concluded that all but one of the proposals demonstrated the ability to provide reliable and stable electric power, water and fuel, and to handle the waste generated.

Now the Invitation for Site Proposals indicates clearly that costs were to be considered as an important but not primary factor in the evaluation of sites. The DOE, working with a contractor, calculated life-cycle costs for each site and provided the results of the calculations to our committee. Determining precisely what is meant by "important, but not primary" might have created significant difficulties for the committee were it not for the fact that, as the committee points out in its report, there was a remarkable narrow range within which the cost estimates provided by DOE fell for the different sites. The committee says that the cost of the most expensive sites was only a few percent above the average for the group and that of the most economical site was only a few percent below the average. Since the range of uncertainty was no doubt at least comparable in magnitude, this obviously weakened considerably the committee's ability to distinguish among the site proposals in terms of the costs that each could be expected to entail.

All of the 35 proposals that we evaluated can be said to have been qualified, at least in the sense of having met the Department of Energy's qualification criteria. The committee was asked to select the best of these. As I have already noted, there were clear and distinct differences among the sites and the extent to which they met the criteria announced in the Invitation for Site Proposals.

Generating the best qualified list, the committee discussed the characteristics of each of the proposals. After the discussion, the committee made an explicit determination whether or not the site merited inclusion on the Best Qualified List. In each case, the members of the committee agreed without dissent on that determination, so that the Best Qualified List represents the best collective judgment of 21 individuals carefully chosen for their broad and varied expertise, experience, and perspective.

The committee feels, as it says in its report, that a productive and effective SSC could be built and operated at any of the sites on the list.

We would be happy to answer any questions.

[The prepared statement of Dr. Kasper follows:]

Statement by

Dr. Raphael G. Kasper

Executive Director,
Commission on Physical Sciences, Mathematics, and Resources
National Research Council
and
Project Director,
Super Collider Site Evaluation Committee

before the

Committee on Science, Space, and Technology
of the
United States House of Representatives

Tuesday, March 22, 1988 - 1:00 pm
Room 2318 Rayburn House Office Building

Of the 43 proposals received by the Department of Energy in September, 1987, 36 were formally transmitted to the Academies for review. (During the evaluation process, one proposal was withdrawn from consideration by New York.) Our committee was asked to evaluate the proposals and to identify "a small number of best qualified sites from among those considered." The committee completed its work in just over three months and prepared a report (Siting the Superconducting Super Collider) that explained its process, presented the best qualified list, and discussed the characteristics of the sites on that list. (I would like to submit a copy of the report for the hearing record.)

It is worth mentioning some aspects of the charge to the Academies that affected the manner in which the committee approached its task. The Department of Energy asked us to complete the review process in three months. Most of you have seen pictures of the proposals arriving at DOE in September and you will recognize that there was an enormous amount of material that had to be read, digested, and evaluated. The members of the committee devoted a substantial portion of their time to the review process, perhaps more than one should expect from a group serving voluntarily and with the demands of their full-time positions continuing unabated during this period, and we met the schedule.

The committee was asked to provide an "unranked" list of the best qualified sites. This precluded the use of detailed numerical schemes in the evaluation, for these would have led, inevitably, to a ranking of the sites. (I should add that this was not the most important or compelling reason for eschewing numerical techniques, but I will return to this point in a moment.)

The committee was to evaluate only the information in the proposals and cost estimates provided by the Department of Energy; additional information in the form of, say, site visits was not to influence the decisions of the committee. Proposers were made aware of this constraint very early in the process; they were to present all information they wished reviewed in the proposals. In at least one sense, the lack of site visits made the committee's task easier; if site visits had been part of the process, equity would have demanded that all sites be visited, and that all members of the committee be involved in all of the visits. There would have been no way to meet the timetable for this project if site visits had been made.

The most significant constraint under which the committee worked lay in the fact that DOE announced, in its Invitation for Site Proposals, the six criteria and 19 subcriteria that would be used in the evaluation process--and the Department also announced the order of importance of the criteria. Again, fairness demanded that there be no change in the criteria or their order of importance, and the committee faithfully adhered to both.

The Academies were asked by DOE to treat the proposals as "confidential", presumably because the evaluation process was part of an ongoing procurement, or procurement-like, process. We have tried to be conscientious about the way in which we have portrayed the proposals in public. With the exception of the required discussion of characteristics of the sites on the best qualified list that appears in the report, we have tried not to make statements about details of the proposals or to characterize strengths and weaknesses of competing proposals. We have discussed with principals involved in individual proposals the characteristics of their sites, but without providing detailed comparisons with other sites.

Before it received any proposals for review, the committee recognized that it was faced with the task of evaluating the proposals using a multiplicity of technical criteria, subcriteria, and costs. Because of the difficulty--some on the committee would have said impossibility--of directly comparing the various criteria and the extent to which individual proposals met or did not meet the criteria, "the committee decided against adopting a rigid set of weights that would allow a mechanical means of scoring or grading proposals." The committee was mindful of the fact that using any other method would highlight "subjective" elements in the process, but it felt first, that the process, by necessity, involved matters of judgment and that it was proper to acknowledge this at the outset, and second, that the use of numbers to grade the criteria introduced only a spurious impression of objectivity and accuracy while entailing every bit as much subjective judgment as any other technique. It was decided, therefore, to evaluate the proposals with respect to any given criterion using the values "good", "satisfactory", and "questionable".

During the period in which proposers were preparing their proposals, our committee discussed the manner in which it would perform its evaluation. We concluded early in the summer that it would be impossible to expect all 21 members of the committee to gain a detailed comprehension of all aspects of all proposals. Therefore, the committee established working groups to focus on each of the six major criteria, and on costs. Each working group was composed of those members of the committee with particular expertise in its area of focus. The working groups were asked to identify strengths and weaknesses of all the proposals in their particular area of concern to form a basis for discussion by the full committee and to provide an initial evaluation of the proposals as an input to the deliberations of the committee.

The report describes how the committee interpreted the criteria announced in the Invitation for Site Proposals; I will not repeat that discussion here, but I will indicate some noteworthy aspects of the criteria and the proposals.

The most important criterion was "geology"--suitability for construction and operation, stability, minimal risks encountered in construction and operation. In general, the proposals were quite good in this area, but although only a handful of the sites presented what appeared to be overwhelming geological problems, there were significant geological distinctions among the sites, and some sites had geological characteristics better suited to the SSC than others.

"Regional resources", the next criterion in order of importance, included a broad range of characteristics of the sites; the committee notes in its report that the components of regional resources "are less amenable to detailed technical analysis than are geological conditions." The report continues:

> The committee was faced with the question of identifying which regional resources are most important to the efficient

and effective construction, start-up, and operation of a major scientific facility and laboratory. The criteria and subcriteria listed by DOE in the ISP are, in general, comprehensive, but they provide little guidance as to which components will be most important to the eventual success of the SSC.

To get a better handle on the issue, the working group on regional resources convened a meeting with directors and representatives of a number of large scientific laboratories to discuss those aspects of community and regional resources that are, in fact, most important in the actual operation of their laboratories--as opposed to those that unexamined, conventional wisdom might highlight. There is much experience in the United States with running large facilities and that experience was quite helpful in fashioning the committee's views. The committee explains its conclusions on this matter in the report.

Environmental impacts of construction and operation were considered. The committee concluded that "no site proposal presented environmental problems that could not be prevented or minimized," but because the sites proposed display such disparate environmental conditions, it is not surprising that there were considerable differences in the impacts that could be expected.

The committee sought help from experts in the Corps of Engineers in its examination of the strengths and deficiencies of the various plans for timely acquisition of the required land and found considerable differences among proposals. Some of the plans were quite complicated and involved acquisition of a large number of small plots; others were simple in comparison.

Regional conditions--natural and man-made conditions that could affect construction and operation of the SSC--were reviewed. Again, there were significant differences among the sites, although the committee concluded that "no site was characterized by such negative regional conditions that it could be eliminated on this basis alone. Thus, for example, at those few sites that had potential noise and vibration problems, it was felt that effective remedial actions were possible."

The last of the technical evaluation criteria was "utilities", and it provided little discrimination among the sites; "all but one of the proposals demonstrated the ability to provide reliable and stable electric power, water, and fuel, and to handle the wastes generated...."

The Invitation for Site Proposals indicates clearly that costs were to be considered as important, but not primary factors in the evaluation of sites. The DOE, working with a contractor, calculated life cycle costs for each site and provided the results of the calculations to our committee. Determining precisely what is meant by "important, but not primary" might have created significant difficulties for the committee were it not for

> ... the remarkably narrow range within which cost estimates for the different sites fell. The cost of the most expensive sites was only a few percent above the average for the group, and that of the most economical site was only a few percent below the average. Since the range of uncertainty was no doubt at least comparable in magnitude, this obviously weakened considerably the committee's ability to distinguish among the site proposals in terms of the costs each could be expected to entail.

All of the 35 proposals can be said to have been qualified, at least in the sense of having met the Department of Energy's "Qualification Criteria." The committee was asked to select the "best" of these. As I have already noted, there were clear and distinct differences among the sites and the extent to which they met the criteria announced in the Invitation for Site Proposals. In generating the best qualified list, the committee discussed the characteristics of each of the proposals. After the discussion, the committee made an explicit determination of whether or not the site merited inclusion on the best qualified list. In each case the members of the committee agreed, without dissent, on that determination. The best qualified list represents the best collective judgment of 21 individuals, carefully chosen for their broad and varied expertise, experience, and perspective. The committee notes that "a productive and effective SSC could be built and operated at any of the sites on the list."

PANEL 2: DISCUSSION

The CHAIRMAN. Thank you very much.

Let me ask just a couple of quick questions.

Was there any predetermined number of sites given to the Academy by the Department of Energy that should get on the short list?

Dr. PRESS. No.

The CHAIRMAN. Okay. When we talked about costs were to be considered but not to be considered to the extent of being the primary determination, what was the variance there in different sites? Do you recall offhand?

Dr. KASPER. I don't remember the exact number—

The CHAIRMAN. Extensive or—

Dr. KASPER. No. The variance was within a couple of percent.

The CHAIRMAN. In other words, one issue offset the other as you went through with it?

Dr. KASPER. All of the costs fell in a fairly narrow band of cost as the estimates were presented to us, and it seemed that the band was larger than the probable uncertainties in those estimates.

The CHAIRMAN. Did you have support personnel, and if so, where do the support personnel—I can envision, having had a similar type of thing, not to this magnitude, in my own career, and you look at it with—aghast, with a truckload of material to be done in a given period of time.

Did you have any support personnel?

Dr. KASPER. There were a number of members of the staff of the National Academy of Sciences and National Academy of Engineering that worked with the committee.

The CHAIRMAN. Okay. But—

Dr. KASPER. In addition, we hired a small number of consultants, particularly to help with the geological evaluation and, as I mentioned, the Corp of Engineers reviewed the site acquisition plans.

The CHAIRMAN. Any Department of Energy personnel there in direct support at all?

Dr. KASPER. The Department of Energy appeared at the first meeting of the committee to explain the SSC project, but other that, the Department as the Under Secretary mentioned kept an arms-length relationship with the committee.

The CHAIRMAN. One, two more points and then I'll defer to other members.

Do you think that three months was a reasonable time to do the work that you had to do, to be effective at it?

Dr. KASPER. Three months was a very short period of time. I think that the committee members put in an awful lot of time. So did the staff, and so I feel that we used the three months to do a very careful and detailed evaluation. I am not sure that if we had had more time the evaluation would have been much different. There would have been less pressure on the members of the committee and the staff to finish quickly. But I think that the evaluation was done carefully and in great detail.

The CHAIRMAN. Let me ask you this: you mentioned the site visitation. Do you think there would have been an advantage if you could—forgetting all the other details—if you had had the opportunity to evaluated each site by visitation?

Dr. **Kasper**. There was some disagreement on this committee about that. We actually discussed that in the committee. Some members thought that it might be valuable to visit sites. Others pointed out that site visits, particularly short ones, for a project like this often result more in ceremonial occasions than in gathering important information.

In any event, though, the proposers were told at the beginning that there would not be site visits, so in a sense it would have been changing the rules to add site visits at a later stage.

The **Chairman**. And one final point and I will defer to the gentleman from Iowa. You said that the decision-making, as I understood it, for clarity, the decision-making process on the members of the site selection group—the Academy—were unanimous in their final work product?

Dr. **Kasper**. That is correct.

The **Chairman**. Okay. Great. Well, the gentleman from Iowa.

Dr. **Press**. Mr. Chairman? May I ask—

The **Chairman**. Yes, Dr. Press.

Dr. **Press**. I have a 5 o'clock appointment with the Chairman of the Senate Budget Committee. I wonder if Dr. White and Dr. Kasper could remain and I could be excused?

The **Chairman**. If you have to be with the Senate Budget Committee, I think it is timely that you meet with the Budget Committee, and we will work the rest of this out, because we are going to need the help of the Budget Committee.

Dr. **Press**. Okay.

The **Chairman**. Thank you very much, Dr. Press.

The gentleman from Iowa.

Mr. **Nagle**. I would like to pick up on maybe the threshold inquiry that I haven't heard asked yet. My understanding is the DOE set the criteria, is that correct?

Dr. **Kasper**. That's correct.

Mr. **Nagle**. Was there any discussion among the committee, the site selection committee, of the review of the DOE's criteria?

Dr. **Kasper**. We were asked, of course, to use the criteria as they were stated. They was no discussion to my recollection that would indicate there was particular dissatisfaction on the committee with those criteria as the important criteria that could be used in the site selection process. But we didn't sit down and ask "Are these the right criteria?" We accepted those as the criteria that all of the proposals were written toward.

Mr. **Nagle**. If the committee were called back together again today, would they—and asked to review the criteria, based now on the experience of having made the investigation and the recommendations, would there be a reasonable, do you feel, reasonable chance that some of the criteria would be changed, some would be weighted differently, different factors to be taken into consideration? I ask that question without any criticism whatsoever. You were here earlier; you know my State is not in it, so I don't have any axe to grind on it. I think you did a fine job, but I am curious if the group of scientists were asked to evaluate for site and were handed the criteria that they were to use, it seems to me an unusual way to go about it.

Dr. **Kasper**. That's a very hard question for me to answer. I certainly can't answer for sure whether the committee would agree precisely with the statement of the criteria.

I do know that there was not any particular evidence during the committee's discussions of any dissatisfaction with those as the criteria, with which they were evaluating the site.

Mr. **Nagle**. Could you describe for us the criteria that you use to select the members to the SCC Site Evaluation Committee?

Mr. **White**. There was obviously a set of expertise that was required. People expert in geology, people expert in the operation of devices of this kind, people knowledgeable about what it would take to track scientists to a location, and in the selection process, we were very careful in trying to collect the expertise together.

In fact, the reason why we had 21 members rather than 15 members is because we felt that we needed more individuals who could bring to the task the breath of expertise that we require.

The listing of the members and their backgrounds and expertises are in the back of this report, starting on Page 50.

Mr. **Nagle**. I confess not to having read it. Are the criteria set out there?

Mr. **White**. Yes, they are, sir.

Mr. **Nagle**. Fine. What was the process that you communicated with each other while this was going on? I thought I heard—

Mr. **White**. Between DOE and the Academy?

Mr. **Nagle**. Just between the committee members themselves.

Dr. **Kasper**. There was listed in the report the committee that the meetings the committee had, so a good deal of the interaction was done at meetings. They also used mails and telephone.

Obviously, a good deal of the committee's work was spent going through this large volume of material to digest and understand the proposals. That was done by individual members working as individuals, for the most part.

Mr. **Nagle**. Did you keep notes or minutes while you were meeting?

Dr. **Kasper**. There are notes. There are brief notes about each of the meetings and there are reports of the six sub-groups and the cost sub-group that lay out the initial evaluations of those subgroups as to how each proposal met or didn't meet each criterion.

Mr. **Nagle**. Were your recommendations on the qualified sites followed in total by the DOE?

Dr. **Kasper**. Yes, the Best Qualified List was identical to our Best Qualified List.

Mr. **Nagle**. Then those conclusions were communicated by you to them what, in writing, by letter, or—

Dr. **Kasper**. We provided the report to the Department.

Mr. **Nagle**. Did you hold meetings with DOE or simply submit the report?

Dr. **Kasper**. We submitted the report and then the staff of the committee briefed the DOE staff on the conclusions of the report. That's something that the Academies generally do when they provide reports to agencies.

Mr. **Nagle**. Were notes of that meeting kept or was it simply a verbal?

Dr. **Kasper**. It was a verbal meeting.

Mr. NAGLE. Were notes or minutes of that meeting kept or are you aware?

Dr. KASPER. Not to my knowledge.

Mr. NAGLE. Was it part of your job, or I guess my question is, why did you interpret your responsibility so as to brief the states that didn't qualify or de-brief the States that didn't qualify, to the limited extent that you did?

Mr. WHITE. We agreed that it was an obligation of ours to meet with elected representatives, either Members of the House, the Senate, Governors of the States, if they wished additional information, and we have met with groups from four States.

Mr. NAGLE. But, it seems one of the undercurrents here, and again I'm not critical of the work you did, I'm glad you took the task on, but one of the undercurrents we hear is that the decision not to supply these people with sufficient data or, that's a negative, with limited data as to why they weren't qualified and as to why others weren't. I'm just wondering why that decision made rather than just say here were the criteria, here's where the Seven states made it, and here's where we felt you were short?

Dr. WHITE. We were asked by the Department of Energy only to provide the details on the criteria on the Best Qualified List and those are described in this report. We were asked to provide them in an unranked form, and we did.

We agreed that we would meet with principals from the sites that did not qualify and discuss, in any detail they would like, the results of deliberations. We have done so.

Mr. NAGLE. Were there States that you picked the top seven, was number eight, nine and ten relatively close to one through seven or was there a clear market distinction between the first seven and the rest of the field?

Dr. KASPER. The most I can say on that is that the clear mark of distinction was that all 21 members of the committee agreed that each of the eight sites that were put on the Best Qualified List should be on the Best Qualified List and all 21 members of the committee agreed that the remaining sites should not be included on the Best Qualified List.

Mr. NAGLE. Now, the next step, of course, will be down the line here, to do Environmental Impact Statements on all of them, and the next step will be to select one.

Dr. WHITE. That's one of the next steps, yes, sir.

Mr. NAGLE. And that's the one everyone here in the room is concerned about—many in the room are concerned about. But I'm kind of curious that if we pick the wrong one, with criteria that were evolved by the DOE and not the scientific community, we are in a hell of a mess. Are you comfortable to say that if we picked any of the seven or any of the eight on the best qualified list, that that would be the right choice?

Dr. KASPER. The committee makes that exact statement in its report. It says that a productive and effective SSC could be built and operated at any of the sites on the list, and I believe that.

Mr. NAGLE. With minimal variance in costs?

Dr. KASPER. According to the figures that were presented to us by the Department of Energy. We did not do cost estimates on our own.

Mr. NAGLE. This is the same one that did the site selection cost estimates?

[Laughter.]

Mr. NAGLE. Thank you very much.

The CHAIRMAN. The gentleman from California, Mr. Brown?

Mr. BROWN. Thank you very much, Mr. Chairman. Gentlemen, I've already indicated my prejudices in favor of the objectivity of the process that took place.

I would just like to ask a brief question. The members of the committee were quite familiar with existing accelerator sites, both linear accelerators and colliding accelerators, and from their experience, probably had a pretty good idea of what an acceptable site would be.

I wonder if, in evaluating the sites, they made any comparisons either overtly or covertly with existing sites including sites such as CERN, which is somewhat on my mind since I visited it so recently?

Dr. KASPER. There were explicit references during the discussions of the committee to other accelerators and to other large scientific facilities, and to experiences both positive and negative with starting up and operating those facilities. CERN was talked about, SLAC was talked about.

Mr. BROWN. So, in addition to the criteria that are set forth on paper by the Department, they had in their minds at least, the criteria that would be established by the existing sites and how well they had worked in the conditions in which they had been placed.

Dr. KASPER. I think a number of members of the committee had some knowledge of what aspects of the criteria that were laid out by DOE were most important for successful operation of a laboratory. As I mentioned, we actually had a meeting at which we discussed the regional resources criteria and which ones were most important for operation of a number of laboratories in this country and CERN. We had someone from CERN out that way.

Mr. BROWN. Of course, regional resources are in the eye of the beholder. If you like to ski, Colorado or CERN would be good locations; if you like to do something else, another site would be preferable.

I have no further questions, Mr. Chairman.

The CHAIRMAN. The gentleman from Illinois?

Mr. BRUCE. Thank you. I was interested in the fact that the statement you've made that of the 21 members of the panel, all of you unanimously agreed on these seven sites as being the most or the best qualified?

Dr. WHITE. That is correct, sir.

Mr. BRUCE. And in your discussion, did you leave an opportunity for any one to make an eight choice, I mean, did any one have an eighth choice that didn't make the List when they decided to go with the seven instead of making the decision unanimous?

Dr. KASPER. I didn't get a sense that that was the case. We could have had 35 sites, I suppose, because the Department of Energy made clear to us that the outset that they didn't have any particular number in mind.

When we finished going through all of the sites and looked at the list of sites that the committee had agreed unanimously belonged on the Best Qualified List, there were eight sites on that list.

Mr. **BRUCE**. And everyone sort of just came to the conclusion that those were the sites that you want to submit?

Dr. **KASPER**. That's correct.

Mr. **BRUCE**. And I notice in the testimony submitted by this panel that generally there is a thread running through there that there were three things that you all were looking at, one of them was geology, it seemed to me that sites had better geological formations to use than others. Was that the first thing you used to sort of decide which of the best would make the best qualified list?

Dr. **KASPER**. It was stated in the invitation for site proposal that geology would be the most important of the six major criteria and that's what we used.

Mr. **BRUCE**. In regional resources, it just mentioned about—Mr. Brown, about skiing. Were the regional resources you were looking at more like highways, transportation facilities, accommodations, universities, research facilities nearby—that's the sort of regional resources, were you looking at ski trails and beaches?

Dr. **KASPER**. There is an extensive discussion of regional resources in both the invitation for site proposal and our report. In fact, all of those things were included—recreational facilities were included, among the large number of factors including educational, cultural, access questions, questions of the availability of local and regional industrial and construction capability. It was a fairly broad category and all of those things were considered.

Mr. **BRUCE**. And finally, you looked at cost and one of you in your testimony this afternoon cited a paragraph on cost that you say no substantial difference in any of the sites on cost over the lifetime of the project. Is that a fair summation of your conclusion?

Dr. **KASPER**. I think that's a fair summation. I should say we did look at all the other criteria that are laid out as well.

We didn't only look at geology and regional resources, but those were the two that were listed as most important by the Department of Energy in its invitation for proposals.

Mr. **BRUCE**. And I wonder, there seemed to be a decision early on by this siting group that you were not going to use scales or numerical preferences to give geology an eight on one site and then a seven on another site, and go to physical resources—why was that decision made to where you didn't have a better feeling for what each proposal was going to end up as a numerical number, numerical ranking perhaps?

Dr. **KASPER**. I think the committee couldn't think of a way to compare numbers for the very different kinds of criteria that are laid out in the invitation.

They did a very detailed look at the geology of all of the sites and had a very clear picture of the distinctions among the sites and the suitability of the various sites, and they did the same in each of the other criteria, but then they presented their results in terms like good, satisfactory, and questionable rather than numerical rankings because they couldn't figure out a way to put numbers on these things that every one would agree to, or numbers on things that are incommensurate in a sense.

For instance, putting a number on the value of ski trails, or of a nearby research university, or of a nearby large airport.

Mr. Bruce. Keep going, those are all in Illinois and I like that idea. I wonder, there's been some criticism, or at least comment discussion, about the 90 day limit you all had. We all saw the newspapers; each of the Governors seemed to become Joe the Giant when they carried in box upon box of material, and you were given 90 days.

Was 90 days an adequate amount of time to evaluate the proposals? I don't know how many tons of material that you all had to go through?

Dr. Kasper. As I indicated before, I think that we did as careful and detailed a job of analysis as we could have done. If we had had more time, we would have done it under somewhat less pressure, but we probably would have done the same kind of job of evaluation.

Mr. Bruce. And I did not mean that to be in any way critical of your discussion. I just was curious as to whether—I guess there was two questions. Was 90 days an adequate amount of time because we may want to evaluate this project a second time or another project of this size, and maybe DOE can use the occurrence of this evaluation to decide whether or not we want to give 120 days; and secondly, if we had given you six months or two years, do you think the results would have been a great deal different since you unanimously agreed on, the 21 of you, you unanimously agreed on these seven sites.

It's sort of a two part—was 90 days enough and would you have made a different decision if you had had a great deal more time?

Dr. Kasper. We would have welcomed more time, but I think that we would have come to the same conclusion had we had more time.

Dr. White. I should point out that it wasn't just 90 days. There was preparatory work by the committee before the actual receipt of the proposals discussing how they would go about the evaluation.

So, there was additional time taken by the committee prior to the actual receipt of the proposals.

Mr. Bruce. So, you all kind of laid down ground rules before you got the material?

Dr. White. Yes, sir.

Mr. Bruce. How much time would that have been before you really got the material to evaluate itself?

Dr. Kasper. I believe we—the committee was appointed toward the end of April and we received the proposals in September.

Mr. Bruce. I notice in Dr. Press' comments a concern about the division that may have occurred or the disappointment relatively large in some States about the fact that they were not chosen. Do you anticipate that this is going to cause any long-term problems with the Academies or any of the researchers involved, that we've left scars that are going to impact on future decisions of your body?

Dr. White. We hope not. I don't believe it will.

Mr. Bruce. You've never had a chance to evaluate a project, it appears, this big. Have you, on other evaluations, has been put to you by DOE and other times, have you seen this kind of post-selection disappointment before?

Dr. **White**. Well, we have evaluated others as for example, the Fermilab, and I wasn't around at the time so I kind of really can't give you any information about actions of those who were not selected at the time, but I would say that given the number of locations that were not selected, obviously only seven were selected.

I think the comments that we've had and questions that we had have been relatively few. There have just been a small number of States; I think most of the other states have been reasonably content.

Mr. **Bruce**. Thank you, Mr. Chairman.

The **Chairman**. I thank the gentleman from Illinois. Let me ask you just one other question. Did the—of the 21 people that were on the panel, were there any of them that were opposed to this Super Collider to your knowledge?

Dr. **Kasper**. We never asked that question during the—

The **Chairman**. I didn't think you did but that wasn't what my question was.

Dr. **Kasper**. I really don't know the answer to that. We not only didn't ask the question, but I don't think I ever found out. I know there were members who were supporters of the Super Collider but I just don't know.

The **Chairman**. I have no further questions. Now I want to thank you very much for your time and your patience. We appreciate it and we'll have some other questions we'll be sending you a note on.

DR. MAURY TIGNER, DIRECTOR, CENTRAL DESIGN GROUP, UNIVERSITIES RESEARCH ASSOCIATION, LAWRENCE BERKELEY LABORATORY, BERKELEY, CA

The **Chairman** The next witness we have is Dr. Maury Tigner, is that the correct—Tigner, who is the Director of the Central Design Group of the Superconducting Super Collider from California.

Now your statement as I have read it, is in depth and it is technical. We will have it placed in the record in full as you presented it but I think it would be profitable if you could give us a summary and an overview of the issue which would be most helpful to the Members.

Dr. **Tigner**. Thank you very much, Mr. Chairman. I'll be happy to try to do that. In fact, to give a rounded view, I made the written statement the way it was although I knew that in your invitation you particularly wanted to hear about the magnet program and about the resources required to carry that out, and that's what I intend to present to you today, and if you want to follow along, I'll—

The **Chairman**. Can you pull your microphone closer, Doctor, it's hard to hear.

Dr. **Tigner**. Is it on?

The **Chairman**. That's better. Thank you.

Dr. **Tigner**. In order to abbreviate the statement in view of the time and to cover the materials which you indicted in your invitation you wished to hear about, I would propose to start on about Page 9 of the written material which I have submitted to you, under the title of Magnet Program.

The 7,680 superconducting diopole magnet units form the principal technical system of the SSC and has been a primary focus of the preparatory R&D program.

As you know from past presentations to this committee, our Reference Design Study for the whole SSC facility was carried out in 1984.

Preliminary studies show that superconducting magnet technology offered economies and capital and operating costs by comparison with standard magnet technology.

In the reference design, three alternative styles of magnets were worked up. In a subsequent, even wider ranging study, five different magnet styles were compared.

Model test results as well as analytical engineering and manufacturing studies, were presented to an independent panel of industrial and scientific experts from here and abroad for their recommendation.

The style that the panel recommended in late 1985 was adopted and its further scientific and engineering development has been pursued as resources have permitted.

The cross-sectional view of the adopted style taken at one of the support points is shown in the figure in my testimony, and a slice from one of the central pieces of the magnet has been on the dais for you to examine at your leisure for further details.

Looking at that, you can see that the heart of the magnet is a shaped coil made from multi-strand cable which is tightly clamped in laminated collars that are enclosed in a yolk of magnet steel.

This code mass is contained within a think stainless steel skin which forms a helium vessel. The core of the 55 foot long unit is similar in concept of that of the successful Fermilab, Tethatron, and to that of the HERA proton ring now under construction in the Federal Republic of Germany.

It is our understanding that a similar choice has been made by the Soviets for their UNK collider project now underway near Moscow.

The magnet specifications used in the conceptual design report, were based on the results of a series of six highly successful 15-foot cold-mass models, the cold-mass being the central part of the magnet, as labeled in the picture, as well as on scientific and engineering projections of improvements in the superconducting material and cryogenic insulation technology is applied to the magnet cryostats.

At that time, a systematic development program was envisioned, which could lead to the initiation of full-scale industrial production of the diopoles in 1992.

A summary outline of the diopole plan is shown in the second figure of my written testimony, and I will now review the process today in our development program.

The heart of the magnets is the coil assembly made from the cables of composite strand, containing thousands of filaments. Each one-sixth the size of a human hair, of an alloy of niobium and titanium embedded in the copper matrix.

The performance capability of the magnets depends on the electric current carrying capability of the cables. This in turn depends upon the details of the metallurgical process by which the alloy is formed into wire and cable.

Substantial improvements in this technology have been achieved under the past four years as a result of a purposeful collaboration of interested U.S. firms, universities, and DOE laboratories.

As you can see from the samples which I have placed on the dais for your closer examination, this is a very sophisticated technology, indeed, and it involves metallurgical manipulations of the material, even on the atomic scale.

The increases in current-carrying capacity shown in Figure 3 have met our goals and have made American manufactured superconducting cable the best in the world.

R&D in the next year will focus on large scale process optimization to maximize the yield, and minimize the costs.

The cryogenic envelope, or cryostat, which permits operation of the magnet core, or code massive helium temperatures, with very low refrigeration powers also is shown in Figure 1. It consists of an outer shell inside of which are excessive layers of temperature control shields and advanced multi-layer insulation blankets.

The most important feature is the re-entrant post assembly which supports the weight of the magnet, fixes its position and permits very little heat transfer to the outside world through use of recently developed high-strength composite materials.

Engineering calculations made at the time of the Conceptual Design Report led us to project an improvement in unit heat leak of better than six times over the then existing technology.

This has been achieved and practiced through the R&D program and the cryostat is now ready for industrial engineering and manufacturing design.

In the way of the magnet cold mass, system requirements for the magnets include not only achievement of the design bending strength, but also other properties necessary for accelerator service.

The magnetic field must be aligned with great precision and be very uniform. The electrical insulation must be sufficient for all possible operating and upset conditions, and the heat load must be very small, as noted previously.

In addition, the interior temperature must be held below the deformation temperature at the structural materials under all operating and upset conditions. The number of training cycles needed for a newly made magnet to achieve full operating strength must be small, and that training must be retained when the magnets are warmed.

Ultimately, of course, the manufacturing process must be optimized for a high rate of industrial production. The three-pronged approach to achievement to these desiderata has been envisioned since early in the conceptual design and is now in process.

The first part of this, a study and verification of the improved superconducting materials and cold mass assembly details, a series of short models of full cross-sectional dimension have been put together and tested.

All of the needed operating and characteristics have been met or exceeded. Concurrently, full length prototypes have been put together and tested and many of the required properties have been met or exceeded.

The first two of the now completed four prototypes achieved 85 percent of the design strength. The second two prototypes achieved the full design strength while requiring too many training cycles. One of them exhibited a breakdown of the electrical insulation.

All of the requirements were met. The status is summarized in Table I. Measurements to date indicate that the differences between the short and the long magnet performances are due to the redistribution of the forces, brought about by scaling out the length.

Feedback from measurements on these first prototypes is now put into the program and instrumented prototypes which deal with this redistribution will soon be tested as the next step in the plan program.

Three new prototypes are essentially ready for test and two more are in an advanced stage of preparation.

A route map for this section of the program showing how we will proceed from here to the beginning of industrial production, is shown in Figure IV.

As a third leg of the program, I note that sub-assemblies and components of the magnets are supplied now by industry.

The third program element needed to complete preparation is the involvement of industry in the engineering and manufacturing design and in the assembly of the completed magnets as well.

A three phase program for accomplishing this goal and the actual manufacture of the magnets in industry was shown in Figure 2. The first phase, which we hope can be well along by the end of this year, will disseminate all of the available technical information to industry and engage its intellectual resources in the magnet technology.

The second phase, which we hope will be underway next year, will result in pre-production prototype magnets of industrial design and provenance.

With the good start and planned program that we have, initiation of full-rate collider dipole production in 1992 can be achieved. The near-term resources needed on the critical path sequence of technical accomplishments required to complete the Super Collider facility are outlined in the next sections.

Plans for the collider magnet program have been referred to above. They form part of a broader program of work on technical systems that come both under the rubric of R&D and Construction in the DOE nomenclature.

Resources requested for the R&D portion of this work are shown in Table II below, totaling to the familiar figure of $64 million and as you can see from that abbreviated table, by far the largest share of that program goes into the superconducting magnet development program, and in order to make that more clear, I have expanded that table in the form of Table III, which shows how those requested resources would be allocated if they were appropriated.

In addition, I have included for your information Table III which gives words which describe in more detail each of the budget lines mentioned in these tables.

In summary, I may say the SSC has been meticulously planned, beginning in 1983, inspired by the scientific need for this facility to be on stream in the mid-1990's. The conceptual design and the subsequent R&D program have provided the needed technical foundation for proceeding with its realization. The plans presented for fiscal year 1989 key into a broader plan for how the SSC may be realized technically under the resource profile put forward previously by the Department of Energy.

A summary schedule of the milestones and technical activities is shown in Figure V. The sequential critical path nature of the technical activities is indicated in Figures VI and VII. Orderly progress on these intimately interleaved paths requires a strong start on the essential engineering now and that is what is being requested.

Thank you, sir.

[The prepared statement of Mr. Maury Tigner follows:]

Statement of Maury Tigner
SSC Central Design Group
Universities Research Association

before
The House Space, Science, and Technology Committee

March 22, 1988

Mister Chairman, Members of the Committee: Thank you for the opportunity to report to you again on the Research and Development Program for the Superconducting Super Collider.

Over the past two decades, the age-old struggle to describe and comprehend the nature of matter has been rewarded by a radically new and simple picture of Nature on the most basic level. This progress has been in large measure stimulated by experimental results from the particle accelerators at Brookhaven, Cornell, Fermilab, and Stanford in the United States, and from other machines abroad. We have learned that all matter in its diverse forms is assembled from a few basic building blocks called quarks and leptons. All known natural phenomena can be described in terms of a few fundamental forces acting among these basic constituents. These insights not only provide a framework for describing and understanding the world around us, but also elucidate the first instants after the creation of the universe.

As our conception of matter based on quarks and leptons has become better established, we have become increasingly aware of its shortcomings. Since the late 1970's, the international scientific community has recognized the need for a next step in understanding the nature of matter and the laws which govern its behavior. Physicists do not believe that within the energy range now available there will be enough clues for us to piece together a fundamental theory of the nature of matter. This conviction, together with our awareness of the value of exploration, our appreciation of the countless instances when unexpected, puzzling, and illuminating new observations have come out of accelerator experiments, is what motivates the quest for higher energies, for a microscope of higher magnification.

I present to you today plans for 1989 geared to making this essential new instrument—the SSC—available for scientific exploration in the mid-1990's.

A BRIEF HISTORY

Although the scientific need for a step to much higher energies was already apparent, in broad terms, a decade ago, it was necessary to develop the technical means to take that step. Formal studies of the feasibility of a multi-TeV accelerator began with workshops sponsored by the International Committee on Future Accelerators at Fermilab in 1978 and at CERN in 1979. Various possibilities for very high energy accelerators, including proton-proton colliders at tens of TeV per beam, were examined. The idea of the SSC itself began to take shape at the 1982 Summer Study on Elementary Particle Physics and Future Facilities organized in Snowmass, Colorado, by the Division of Particles and Fields of the American Physical Society. The SSC initiative was followed up with workshops on accelerator and detector issues held during 1983 at Cornell University and the Lawrence Berkeley Laboratory.

It was in this setting, and encouraged by the successful operation of the Fermilab Tevatron, the first superconducting synchrotron, where protons have been boosted to energies of nearly one trillion electron volts, that a High Energy Physics Advisory Panel Subpanel on Future Facilities formulated its recommendation for "the immediate initiation of a multi-TeV high-luminosity proton-proton collider project with the goal of physics at the earliest possible date." This recommendation was transmitted to the Department of Energy with the unanimous endorsement of HEPAP in July of 1983. The DOE responded by initiating preliminary R&D toward the SSC in the fall of that year.

In December 1983, the DOE and the Directors of the U.S. high-energy physics laboratories chartered a Reference Designs Study to produce example designs of a proton-proton collider with energy of 20 TeV per beam and luminosity of 10^{33} cm^{-2} s^{-1}. Three different approaches were investigated, and it was found that any of them could form the basis of a technically feasible SSC, at a cost of approximately three billion (FY84) dollars.

Early in 1984, the Department of Energy contracted with Universities Research Association, a consortium of 66 leading research universities, to direct and coordinate the SSC research and development program. For this purpose, the SSC Central Design Group was established, accepted the hospitality of the Lawrence Berkeley Laboratory, and began work on a non–site-specific conceptual design. Participants included Brookhaven National Laboratory, the Fermi National Accelerator Laboratory (Fermilab), Lawrence Berkeley Laboratory, the Texas Accelerator Center, and experts from many laboratories and universities in Canada, Western Europe, Japan, and the United States. American industrial firms also played an important role.

Approximately 8000 dipole magnets will generate the magnetic field that keeps the protons circulating around the SSC collider rings. An early goal was, therefore, to determine the basic dipole magnet style. In September 1985, after several different concepts had been developed and studied, a high-field superconducting magnet in which the field is defined by the placement of the superconductor was adopted as the basis for the conceptual design.

Simultaneously, all accelerator and conventional systems (other than detectors) were defined and assessed. The completed Conceptual Design Report (CDR) details the scientific, technical, and cost aspects of the project. Since its publication in March 1986, the Conceptual Design Report (SSC-SR-2020) has been extensively reviewed by independent experts. This document has served as the basis for continuing SSC R&D. I shall review here the progress of the R&D program since publication of the CDR.

Shortly after President Reagan endorsed the SSC as a national goal in January 1987, the Department of Energy began the process of selecting a location for the SSC laboratory. The technical work coordinated by the Central Design Group is complementary to the site selection being carried out by the DOE with advice from the National Academies of Sciences and Engineering. The CDG has essentially no role in that work; I will, therefore, not discuss it further except to note certain milestones and schedule items associated with site selection.

DESCRIPTION OF THE SSC

The SSC is a chain of accelerators, linked to boost barely moving protons to nearly the speed of light. The particles reach increasingly high energies in a cascade of four accelerators that make up the injector, from which they are fed into the collider ring.

The collider ring is the heart of the SSC. In this underground oval tunnel, 10 feet in diameter and 53 miles in circumference, two beams of protons are accelerated in opposite directions. The protons travel in compact bunches, with billions of protons in each bunch. Each second, the fifteen thousand bunches that fill each beam pipe make three thousand laps around the ring. On every lap, a pulse of radio waves boosts the energy of each bunch, until they reach their final energy—twenty trillion electron volts. The circulating beams are maintained at that energy and focused into head-on collisions where detectors can record particles produced from the energy of the collision.

Superconducting electromagnets in the collider ring guide each proton beam through a stainless steel pipe about one and a quarter inches in diameter. Magnets curve the paths of the beams, making it possible to build the accelerator in a loop, rather than a straight line, and thus realize substantial economies by repeatedly using the same components to accelerate and manipulate the beam. In the collider ring of the SSC, the same accelerating station gives the beam a push three thousand times each second.

Superconducting magnets are used because they make possible substantial savings. At low temperatures, certain materials become superconductors, in which electricity is able to flow without resistance. Such a material, an alloy of niobium and titanium, will be used to fabricate the coils for the SSC magnets. The magnets will be operated at the temperature of liquid helium, about 4 degrees above absolute zero. Once these magnets are turned on, electric power is only required to drive the refrigerators that keep them cold. This is less than one percent of what would be needed to power conventional electromagnets built from copper cable.

In addition, superconducting magnets can create magnetic fields several times stronger than conventional magnets, thus confining the protons to a tighter orbit and reducing the ring's perimeter.

An important benefit of the cryogenic system is its contribution to maintaining the vacuum in the beam pipe. If the protons bumped into air molecules as they traveled around the ring, they would lose energy and be deflected from their proper orbit. The liquid helium for the superconducting magnets bathes the outside walls of the beam pipe and lowers its temperature. Any stray molecules inside the pipe tend to adhere on the cold inside walls of the beam pipe, out of the protons' way, just as a damp finger sticks to an ice cube.

At the interaction regions the two beams are steered into head-on collision. Experimental apparatus at these points is designed to provide two kinds of information: to identify the particles produced in the collisions by measuring their properties, and to determine as precisely as possible the path each particle followed. Although similar in concept to existing detectors, SSC detectors will be physically larger and more complex than previous experiments. Using a large array of state-of-the-art components, international teams of physicists and engineers will design, construct, install, and operate the experimental apparatus at the SSC.

Precise control is necessary to coordinate the five accelerators that make up the SSC chain, and to ensure that the magnets, power supplies, refrigerators, and control devices function in harmony. Special instruments monitor these systems and relay their observations electronically to a distributed complex of computers.

THE R&D PROGRAM

For the past two years, the Central Design Group has coordinated a multi-fronted assault on the challenge of refining a technically assured, economically optimal conceptual design. A team of scientists, engineers, and technicians from around the country has been engaged in bringing the idea of the SSC to reality. These have been exciting times for all involved, and I am pleased to offer a brief summary of some of the highlights of this work.

THE ACCELERATOR

Accelerator designers associated with the SSC have had several important tasks: refinement of the design of the accelerator itself, the detailed specification of performance requirements for technical components, and the development of algorithms to monitor and control the performance of the accelerator complex.

All the way around the 53-mile long tunnel, the SSC beams must be accurately guided along the center of the beam pipes. The magnets must be carefully laid out to achieve this with optimum beam quality and cost. We have now designed a pattern for the magnets in each of the two large, semi-circular regions of each ring (arcs) that confines the beam into a cylinder 0.068 cm in diameter, well within the aperture of the beam pipe.

More sophisticated optics are required to focus the beams into even tighter bunches at the collision points. To produce the desired high collision rate, beams at the collision points are compressed into cylinders smaller than a human hair. A special modular design has been devised that not only squeezes the diameter of the beams but is also extremely flexible, allowing a wide range of collision conditions appropriate for different types of experiments.

An important design decision for a circular accelerator is the size of the magnet aperture through which the beam travels. Although the cost of building magnets increases with the diameter of the required uniform magnetic field, high magnetic field quality, which determines beam stability, becomes more difficult to attain as the aperture is decreased. Accelerator physicists at the Central Design Group first developed detailed theoretical tools—both numerical and analytical—to examine a range of possible apertures. They then tentatively chose a beam pipe with an internal diameter of 3.3 cm as the most cost-effective for the SSC.

To check the predictive power and accuracy of the theoretical calculations, and to establish criteria for evaluating the SSC aperture, a team of accelerator physicists from the Central Design Group, CERN, Cornell University, Fermilab, and SLAC has been conducting a series of experiments at the Fermilab Tevatron. In a typical aperture experiment, the circulating beam is given a sudden kick that causes it to oscillate about its equilibrium orbit, while special sextupole magnets of known strength are powered to mimic the SSC environment. A pair of beam position monitors registers turn-by-turn beam position data after the fast kick for up to a few hundred thousand turns.

When the experiments are completed, we will be able to confidently set the magnet aperture. Any changes that might be required would be small and would not have a significant cost impact. The knowledge gained in accelerator physics, particularly nonlinear dynamics, should prove valuable for all circular accelerators and for other particle beam devices.

ACCELERATOR SYSTEMS

Several technical challenges posed by the collider's superconducting magnet support systems have been addressed in the past two years. Results of experiments, calculations, and studies increase our confidence that commercially available components can meet many of the requirements of these systems.

The SSC will have the world's largest helium refrigeration system. The superconducting magnets must be maintained at the chosen operating temperature of 4.35 K under a variety of operating modes and conditions.

To allow construction, installation, and commissioning to be performed in parallel, we have designed a system of units capable of independent operation but interconnected for redundancy. The present design calls for ten cryogenic units or sectors for the collider ring, plus an eleventh to service the injector. Each sector requires a cryogenic refrigeration capacity of the equivalent of about 7500 watts at 4.35 K, within current industrial practice.

However, the SSC cryogenic system presents a significant challenge in process control. It must not only produce and deliver the cooling required for normal operation of the collider, but also accommodate such transient thermodynamic conditions as cooldown, magnet quench, and beam acceleration. In addition, it must function reliably to meet the design requirement that beam be available for experiments at least 80 percent of the time.

With help from industry, the Central Design Group has undertaken two computer simulations of the SSC's cryogenic system. In the first, refrigeration plant concepts are investigated by static process simulation: a base operating plant flow sheet was developed and studied in a variety of operating modes. More recently, we began to model the behavior of the cryogenic system as a whole: the refrigeration plant design is simplified, and the behavior of transient conditions in one cryogenic sector of the collider and the cryogenic interactions between sectors can be analyzed. Both simulations are important for a final engineering design. Modeling confirms the adequacy of initial design concepts, aids instrumentation and control systems design, and assists the task of writing specifications. It also provides a tool for judging design proposals and helps assure that a self-consistent set of specifications has been produced.

THE DETECTORS

To answer our questions about the structure of matter, the SSC must have a high collision rate, so that studies can be carried out efficiently. About 100 million proton-proton collisions will occur every second at the SSC, some of which will produce hundreds of particles. Identifying these evanescent products requires measuring their energies and directions.

To achieve this goal, many-layered detectors surround the interaction region. Typically, closest to the collision point a detector with good spatial resolution tracks the many closely spaced particles emerging from the collision. Another layer measures the curved paths that electrically charged particles follow in a magnetic field. The energy and direction of both charged and neutral particles or groups of closely spaced particles is measured by the outer layers. In every layer, high spatial resolution is important to enable different products to be distinguished.

Storing and studying the data from every collision would, of course, be impossible. Sophisticated electronics and computer systems filter the data and discard phenomena that are already well understood, just as in daily life we pay closer attention to unusual occurrences than to the mundane. Only a handful of interesting collisions per second are recorded permanently.

The SSC's high event rate, the large number of tracks per event, and the need to resolve the tracks of different particles that have similar energy and direction present a challenge to detector technology. To meet this challenge, new detection and information-processing techniques must be developed or older methods improved.

Detectors for the SSC must be colossal to trap the very high energy particles that the SSC will create: an SSC detector might weigh as much as 50000 tons and be as tall as a five-story building. Despite this enormous physical scale, research and development of detector technology can be carried out by small groups of physicists and engineers at universities and laboratories. Productive collaboration with industries involved in silicon detectors, advanced electronics and computing, scintillating materials, and many other areas is vital.

At present, detector research includes the development of high-speed, two-dimensional silicon detectors (pixel devices) and the associated "smart" readout electronics that record only selected data; custom integrated circuits for low-noise, high-speed applications; new radiation-resistant scintillating materials; large-volume, high-field superconducting magnets for experiments; and new large-scale methods for precise measurement of particle energies and directions by calorimetry. Initial work is being pursued in more than a dozen universities and in five high-energy physics laboratories across the country, involving collaborations with scientists in Canada, Japan, and Europe. As the opportunity for university and laboratory involvement is large, the next two years will see a substantial increase in such efforts.

MAGNETS

The 7680 superconducting dipole magnet units form the principal technical system of the SSC and have been a primary focus of the preparatory R&D program.

As you know from past presentations to this Committee, a Reference Designs Study (RDS) for the SSC was carried out in 1984. Preliminary studies showed that superconducting magnet technology offered economies in capital and operating cost by comparison with standard magnet technology. In the RDS, three alternative styles of superconducting magnets were worked up and costs estimates prepared for each. In a subsequent even wider-ranging study, five different magnet styles were compared on the basis of technical characteristics and cost. Model test results, as well as analytical engineering and manufacturing studies were presented to an independent panel of industrial and scientific experts for their recommendation. The style that the panel recommended in late 1985 was adopted as the basis for the Conceptual Design Report (CDR) presented to the Department of Energy in the spring of 1986, and its further scientific and engineering development has been pursued as resources have permitted. A cross-sectional view of the adopted style, taken at one of the support points, is shown in Figure 1. A shaped coil made from multi-strand cable is tightly clamped in laminated collars that are enclosed in a yoke of magnet steel. This cold mass is contained within a thin stainless steel skin which forms the helium vessel. A slice of the collared coil assembly with beam tube is being passed around for illustration. The core of the 55-ft.-long unit is similar in concept to that of the successful Fermilab Tevatron (1983) with its 21-ft. units and to that of the HERA proton ring with its 30-ft. units now under construction in the Federal Republic of Germany. It is our understanding that a similar choice has been made by Soviets for their UNK collider project now under way near Moscow.

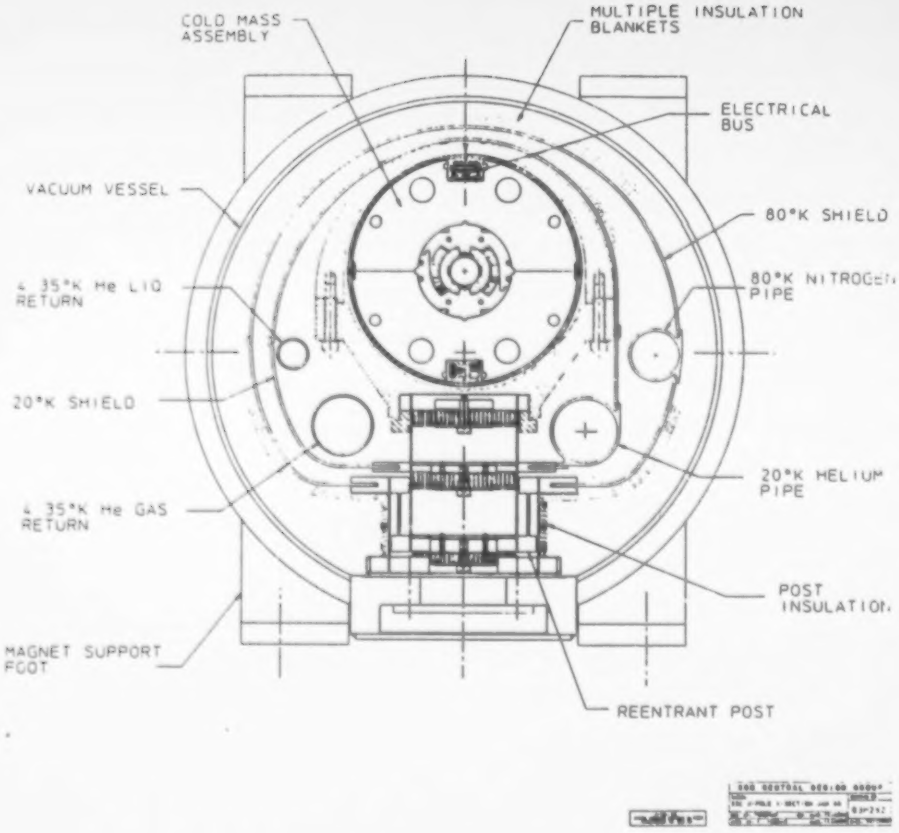

COLD MASS ASSEMBLY
MULTIPLE INSULATION BLANKETS
ELECTRICAL BUS
VACUUM VESSEL
80°K SHIELD
4.35°K He LIQ RETURN
80°K NITROGEN PIPE
20°K SHIELD
20°K HELIUM PIPE
4.35°K He GAS RETURN
POST INSULATION
MAGNET SUPPORT FOOT
REENTRANT POST

Figure 1. SSC collider dipole cross section.

The magnet specifications used in the CDR were based on the results of a series of six highly successful 15-ft. cold mass models, as well as on scientific and engineering projections of improvements in the superconducting material and cryogenic insulation technology as applied to magnet cryostats. At that time an iterative, systematic development program was envisioned which could lead to the initiation of the full scale industrial production of the dipoles in 1992. A summary outline of the dipole plan is shown in Figure 2. Following is a review of progress to date in the development program.

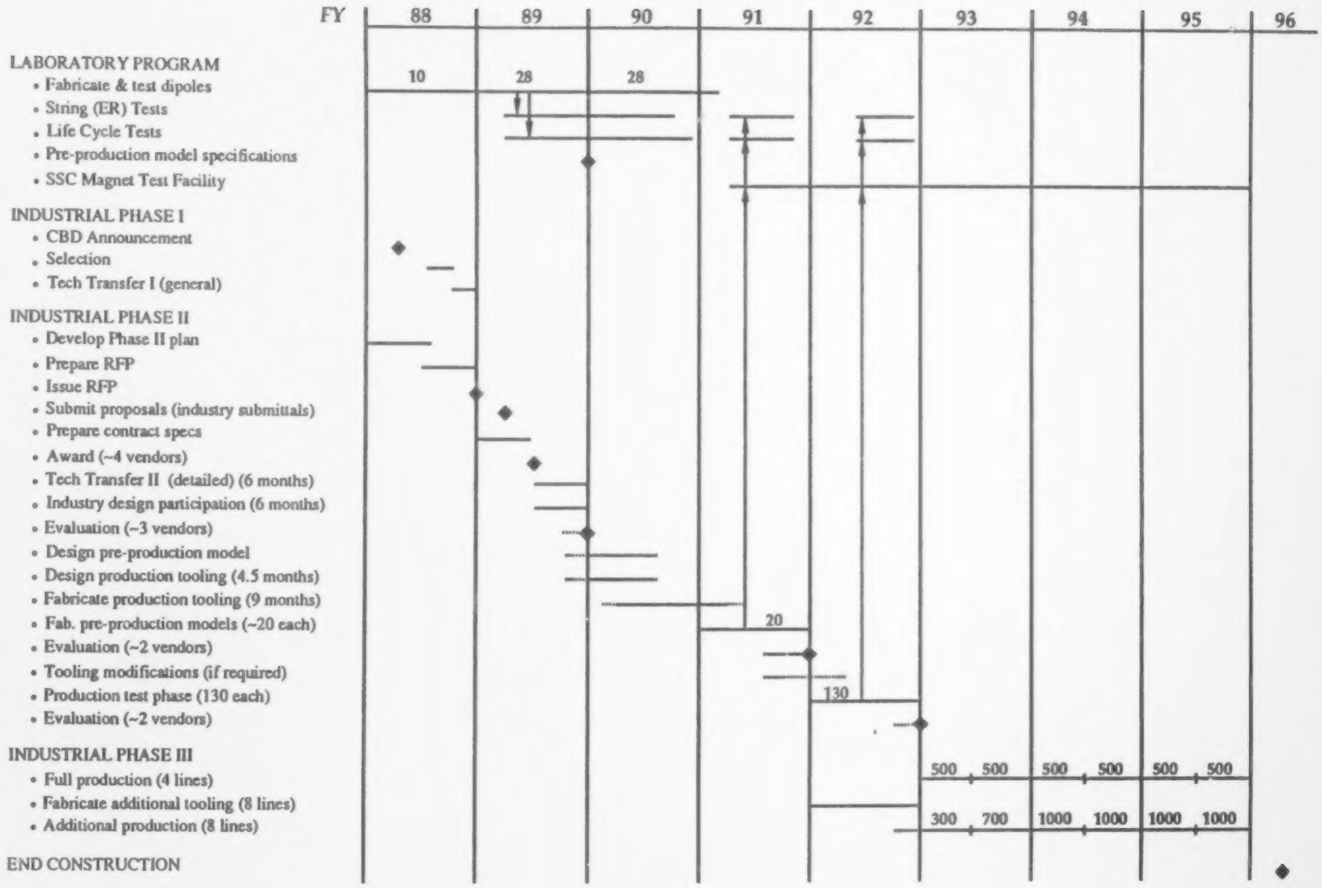


Figure 2. SSC collider dipole plan.

Conductor

The heart of the magnets is the coil assembly made from cables of composite strands containing thousands of filaments—each one-sixth the size of a human hair—of an alloy of niobium and titanium embedded in a matrix of copper. The performance capability of the magnets depends on the electric-current-carrying capability of the cables. This in turn depends upon the details of the metallurgical processes by which the alloy is formed into wire and cable. Substantial improvements to this technology have been achieved over the past four years as a result of a purposeful collaboration of interested U.S. firms, universities, and DOE Laboratories. As you can see from the samples being passed among you, this is a very sophisticated technology. It involves metallurgical manipulations of the material at the atomic scale. The increases in current-carrying capacity shown in Figure 3 have met our goals and made American-manufactured superconducting magnet cable the best in the world. R&D in the next year will focus on large-scale process optimization to maximize the yield and minimize the cost.

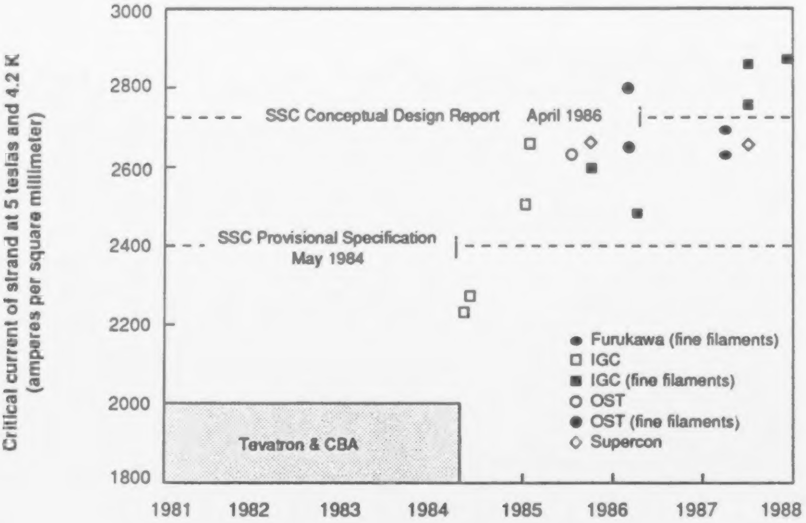


Fig. 3. NbTi superconductor for SSC magnets.

Cryogenics

The cryogenic envelope or cryostat, which permits operation of the magnet core or cold mass at helium temperature with very low refrigeration power, is also shown in Figure 1. It consists of an outer shell, inside of which are successive layers of temperature-controlled shields and advanced multi-layer insulation blankets that surround the cold mass and the piping that carries the helium coolant to and from the magnet chain. A most important feature is the re-entrant post assembly which supports the weight of the magnet, fixes the position, and permits very little heat transfer by use of recently developed high-strength composite materials. Engineering calculations made at the time of the CDR led us to project an improvement in unit heat leak of better than six times over then-existing technology. This has been achieved in practice through our R&D program, and the cryostat is now ready for industrial engineering and manufacturing design.

Magnet Cold Mass

System requirements for the magnets include not only achievement of the design bending strength, but also other properties necessary for accelerator service. The magnetic field must be aligned with great precision and be very uniform. The electrical insulation must be sufficient for all possible operating and upset conditions, and the heat load must be very small as noted previously. In addition, the interior temperature must be held below the deformation temperature for the structural materials under all operating and upset conditions, the number of training cycles needed for a newly made magnet to achieve full operating strength must be small, and that training must be retained when the magnets are warmed. Ultimately, the manufacturing process must be optimized for a high rate of industrial production.

A three-pronged approach to achievement of these desiderata has been envisioned since early in the conceptual design and is now in process:

a) For study and verification of improved superconducting materials and cold mass assembly details, a series of short models of full cross-sectional dimensions have been put together and tested. All of the needed operating characteristics have been met or exceeded.

For example, using the newly developed cables, field strengths of more than 7.2 teslas have been reached at the SSC design operating temperature. This is to be compared with the SSC target of 6.6 teslas. As a trial of the ability of the basic mechanics of these magnets to withstand the magnetic forces encountered in operation, the test temperature has been lowered to enhance the capacity of the superconducting material. Under these circumstances, fields of greater than 9 teslas have been achieved.

b) Concurrently, full-length prototypes have also been put together and tested, and many of the required properties have been met or exceeded. The first two of the four now-complete prototypes achieved 85 percent of design strength. The second two prototypes achieved design strength, albeit requiring too many training cycles for this achievement. One of them exhibited a breakdown of electrical insulation. All other requirements were met. This status is summarized in Table I. Measurements to date indicate that the differences between short and long magnet performances are due to the redistribution of the forces brought about by scaling up the length. Feedback from measurements of these first prototypes is now put into the program and instrumented prototypes which deal with this redistribution will soon be tested as the next step in the planned program. Three new prototypes are essentially ready for test and two more are in an advanced stage of preparation. A route map for this segment of the program is shown in Figure 4.

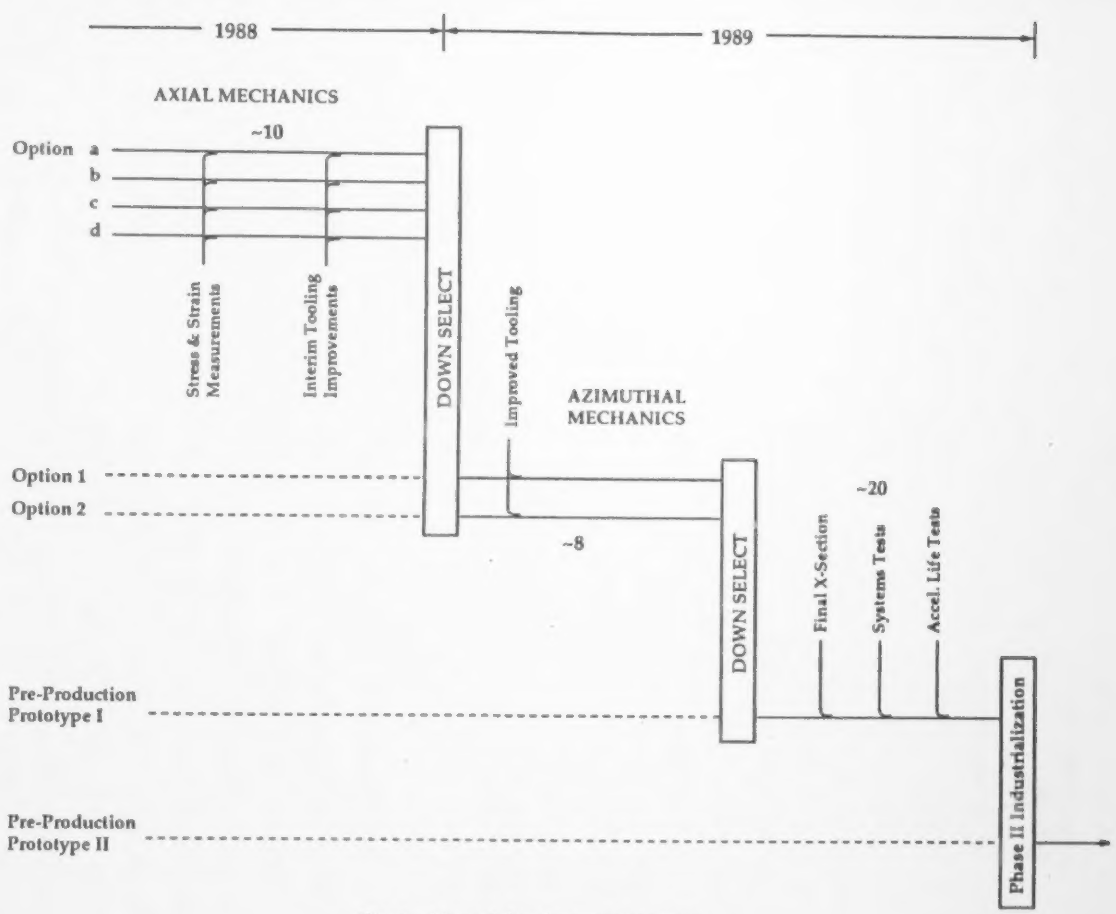

1988
1989
AXIAL MECHANICS
~10
Option a
b
c
d
Stress & Strain Measurements
Interim Tooling Improvements
DOWN SELECT
Improved Tooling
AZIMUTHAL MECHANICS
Option 1
Option 2
~8
DOWN SELECT
~20
Final X-Section
Systems Tests
Accel. Life Tests
Pre-Production Prototype I
Pre-Production Prototype II
Phase II Industrialization

Fig. 4. Magnet development sequence.

Table I. Collider Dipole R&D Status.

REQUIREMENT	STATUS	
	1 to 4.5 m 25†	17 m 4† (66)*
Design Field	OK	1&2 NO 3&4 OK
Field Alignment	OK	OK
Field Uniformity	OK	OK
Electrical Insulation	OK	Must be improved
Heat Load	OK	OK
Max. Quench Temperature	OK	OK
Training Behavior	OK	Needs improvement
Training retention	OK	Not checked
Manufacturing Process Optimization		Planned for initiation in FY 1989

† number complete
* number required to complete planned program

c) Subassemblies and components of the magnets are supplied by industry. The third program element needed to complete preparation is the involvement of industry in the engineering and manufacturing design and in the assembly of the complete magnets. A three-phase program for accomplishing this goal and the actual manufacture of the magnets in industry is shown in Figure 2. The first phase, which we hope can be well along by the end of this year, will disseminate all of the available technical information to industry and engage its intellectual resources in the magnet technology. The second phase, which we hope to have well underway next near, will result in pre-production prototype magnets of industrial design and provenance.

With the good start and planned program that we have, initiation of full-rate collider dipole production in 1992 can be achieved.

The near-term resources needed and critical path sequence of technical accomplishments required to complete the Supercollider facility are outlined in the next sections.

PLANS FOR FY1989

Plans for the collider magnet program have been referred to above. They form part of a broader program of work on technical systems that come both under the rubric of "R&D" and "Construction" in DOE nomenclature. The SSC is an integrated system consisting of an injector comprised of four cascaded accelerators and the collider ring fed by it. The injector complex requires accelerator physics studies as well as some component and subsystem R&D. In the collider ring itself, there are technical systems besides the magnet, such as the cryogenic, acceleration, and control systems. They likewise are ready for R&D and engineering design and development. Also required are engineering studies of the conventional system requirements for these technical systems.

Another important item that needs to be started now is the R&D on detector elements which will be needed for scientific exploitation of the SSC. Accordingly, a budget for this work has been included in the FY 1989 request. These items are listed, together with the requested resources, in Table II.

Table II. FY89 SSC R&D Program Plan (in M$).

	M$
Accelerator Physics	3.0
Injector Systems	3.5
Superconducting Magnet Development	44.0
Collider Technical Systems	5.5
Conventional Systems Development	1.0
Detector Development	7.0
Total R&D (Operating)	64.0
Accelerator Equipment	11.0
Detector Equipment	5.0
Total Equipment	16.0

As you can see, the magnets occupy a prominent position, commensurate with their technical importance in the overall scheme. Table III shows a further breakdown of the magnet component of the R&D request. Table IIIa gives indications of the planned use of the requested resources.

Table III. FY 1989 SSC Superconducting Magnet R&D Program Plan.

	M$
Collider Dipoles	18.2
Industrialization Program	8.0
Collider Quadrupoles	2.3
Collider Spools	2.0
Collider Interaction Region Quadrupoles	1.5
Collider Special Magnets	3.0
Systems Integration	2.0
Cell Tests	2.0
Accelerated Life Tests	2.0
High Energy Booster (Injector) Magnet Systems	3.0
TOTAL	44.0

Table IIIa. FY 1989 SSC Superconducting Magnet R&D Program Plan.

• Collider Dipoles	
– Fabricate, Test, & Analyze	10 Short Dev. Models
– Fabricate, Test, & Analyze	28 Full Scale Models
• Industrialization Program	
– Award Contracts for Phase II Industrialization	
– Begin Detailed Production Designs for Dipoles	
• Collider Arc Quadrupole	
– Fabricate, Test, and Analyze	5 Short Dev. Models
• Collider Spools	
– Fabricate, Test, and Analyze	3 Full Scale Models
• Collider Interaction Region Quadrupoles	
– Fabricate, Test, and Analyze	2 Short Models
• Collider Special Magnets	
– Fabricate, Test, and Analyze For Vertical Dipoles, Dispersion Suppressor Region Quads, and Utility Region Quads	~7 Dev. Models
• Systems Integration	
– Design, Test and Analyze Component Interconnections, Systems Tests, and Systems Operations	
• Cell Tests	
– Complete Facilities Preparations and Begin Tests of Integrated Collider Components (Dipoles, Quadrupoles, and Spools)	
• Accelerated Life Tests	
– Complete Technical Facilities and Execute Life Cycle Tests of Full-Scale Magnet Models	
• High Energy Booster Magnet Systems	
– Complete Model Dipole and Quad Designs	
– Fabricate and Test 2 Dipole Models and 2 Quadrupole Models	

Table IV displays that part of the program request that comes under the rubric of "construction." Note that the great majority of the items concern technical components that are not site-specific and do not require that the work be done at a particular site. For example, the first item concerns collider magnets and would provide for the long lead basic materials and tooling needed for industry to begin producing prototypes. Others of the items, as indicated, are for engineering designs and development of technical components. Table IVa indicates the uses to which the plan would put the requested resources.

Table IV. FY 1989 Construction Plan Obligations (FY89 M$).

	TOTAL PROGRAM	TECHNICAL SYSTEMS (Non–Site-Specific)
1. TECHNICAL SYSTEMS — COLLIDER	67.7	67.7
1.1 S.C. Cable Tooling	1.5	
1.2 Superconductor	13.7	
1.3 Magnet Tooling	29.3	
1.4 Magnet Material	15.6	
1.5 Cryo – Refrigerator	7.6	
2. PLANNING AND DESIGN	31.0	31.0
2.1 Tech Design Groups	22.5	
2.2 Planning – Management and Support	8.5	
3. TECHNICAL SYSTEMS — INJECTOR	56.8	56.8
3.1 Source and Linac	22.3	
3.2 LEB	14.9	
3.3 MEB	19.6	
4. CONVENTIONAL SYSTEMS DESIGN	16.2	7.0
5. CONVENTIONAL SYSTEMS ACTIVITY	89.0	
5.1 Site Preparation	28.9	
5.2 Electrical Distribution	47.5	
5.3 Electrical Procurement	12.6	
6. PROJECT SUPPORT	22.3	22.3
6.1 Support Equipment	20.8	
6.2 Support Facilities	1.5	
SUBTOTAL, non–site-specific technical systems		184.8
TOTAL	283.0	

Table IVa. FY 1989 SSC Construction Program.

A. Technical Systems	
• General	– Complete organizational structure – Mobilize technical design staff – Coordinate design plan with R&D program – Establish monitoring and reporting systems
• Linac	– Start detailed design of major systems – Start fabrication of linac sections, RF systems, and control systems
• 8 GeV Synchrotron (LEB)	– Start detailed design of major systems – Start fabrication of magnets, power supplies, RF systems, and control systems
• 100 GeV Synchrotron (MEB)	– Start detailed design of major systems – Start fabrication of magnets, power supplies, vacuum, and RF systems
• 1 TeV Synchrotron (HEB)	– Start detailed design programs for magnets, power supplies, cryogenics, vacuum, and RF systems
• Collider Ring	– Start design programs for magnets, cryogenics, and power supply systems – Start fabrication and procurement of superconducting cable tooling, superconductor cable, and magnet materials – Contract for magnet test facility
B. Conventional Systems	
• General	– Mobilize design staff – Establish systems specifications – Coordinate with technical requirements – Initiate site preparation work
• Design	– Initiate detailed design for utility systems, roads, injector system structures, and first sector of the collider tunnel
• Construction	– Award contracts for site preparations – Initiate long lead procurements for power and utility systems
C. Project Support	
• General	– Procure equipment required in support of the construction program – Provide facilities to support design effort

SUMMARY

The SSC has been meticulously planned, beginning in 1983, inspired by the scientific need for this facility to be on-stream in the mid-1990's. The Conceptual Design and subsequent R&D program have provided the needed technical foundation for proceeding with its realization.

The plans presented for 1989 key into a broader plan for how the SSC may be realized technically under the resource profile put forward by the DOE. A summary schedule of milestones and technical activities is shown in Figure 5. The sequential, critical-path nature of the technical activities is indicated in Figures 6 and 7. An orderly progress on these intimately interleaved paths requires a strong start on the essential engineering now, and that is what is being requested.

Thank you for this opportunity and your kind attention.

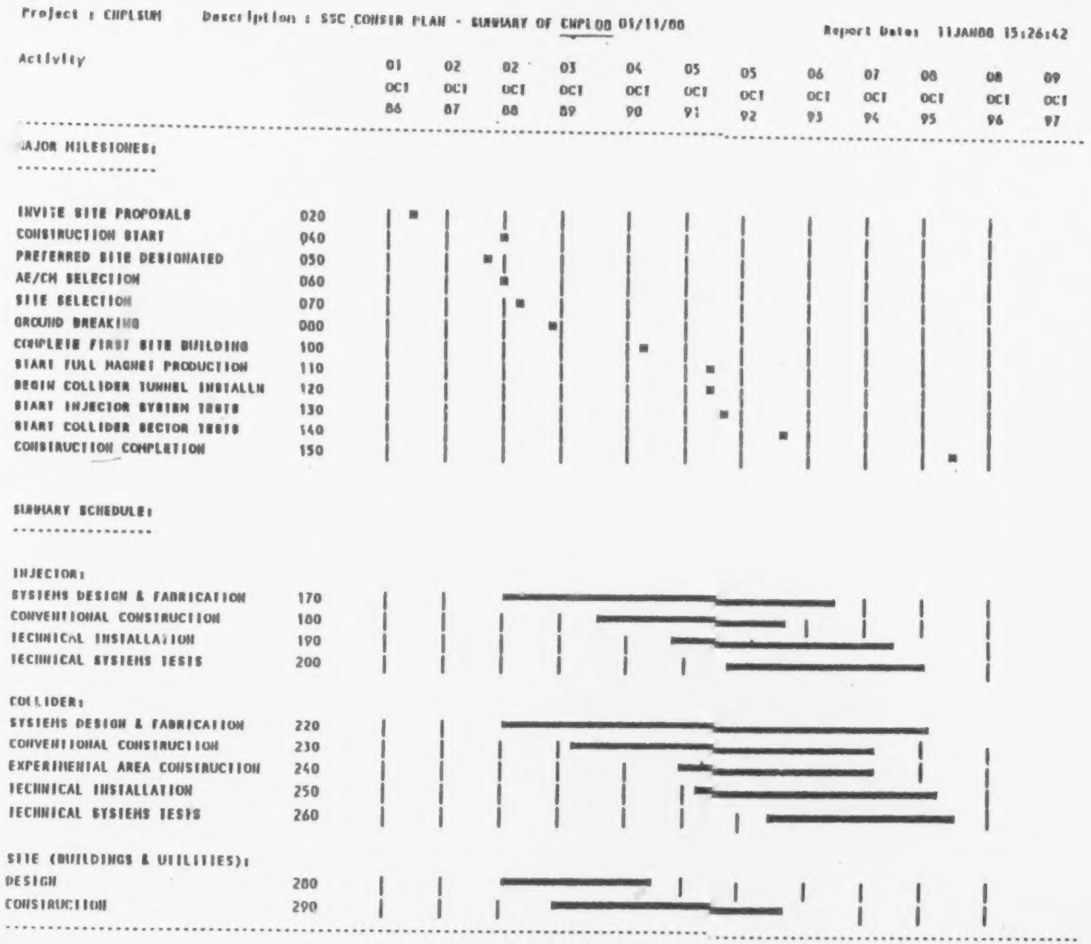

Project : CHPLSUM
Description : SSC CONSTR PLAN - SUMMARY OF CHPL00 01/11/88
Report Date: 11JAN88 15:26:42
Activity
01 OCT 86
02 OCT 87
02 OCT 88
03 OCT 89
04 OCT 90
05 OCT 91
05 OCT 92
06 OCT 93
07 OCT 94
08 OCT 95
08 OCT 96
09 OCT 97
MAJOR MILESTONES:
INVITE SITE PROPOSALS 020
CONSTRUCTION START 040
PREFERRED SITE DESIGNATED 050
AE/CM SELECTION 060
SITE SELECTION 070
GROUND BREAKING 080
COMPLETE FIRST SITE BUILDING 100
START FULL MAGNET PRODUCTION 110
BEGIN COLLIDER TUNNEL INSTALLN 120
START INJECTOR SYSTEM TESTS 130
START COLLIDER SECTOR TESTS 140
CONSTRUCTION COMPLETION 150
SUMMARY SCHEDULE:
INJECTOR:
SYSTEMS DESIGN & FABRICATION 170
CONVENTIONAL CONSTRUCTION 180
TECHNICAL INSTALLATION 190
TECHNICAL SYSTEMS TESTS 200
COLLIDER:
SYSTEMS DESIGN & FABRICATION 220
CONVENTIONAL CONSTRUCTION 230
EXPERIMENTAL AREA CONSTRUCTION 240
TECHNICAL INSTALLATION 250
TECHNICAL SYSTEMS TESTS 260
SITE (BUILDINGS & UTILITIES):
DESIGN 280
CONSTRUCTION 290

Figure 5

SSC SUMMARY SCHEDULE of MAJOR TECHNICAL SYSTEMS

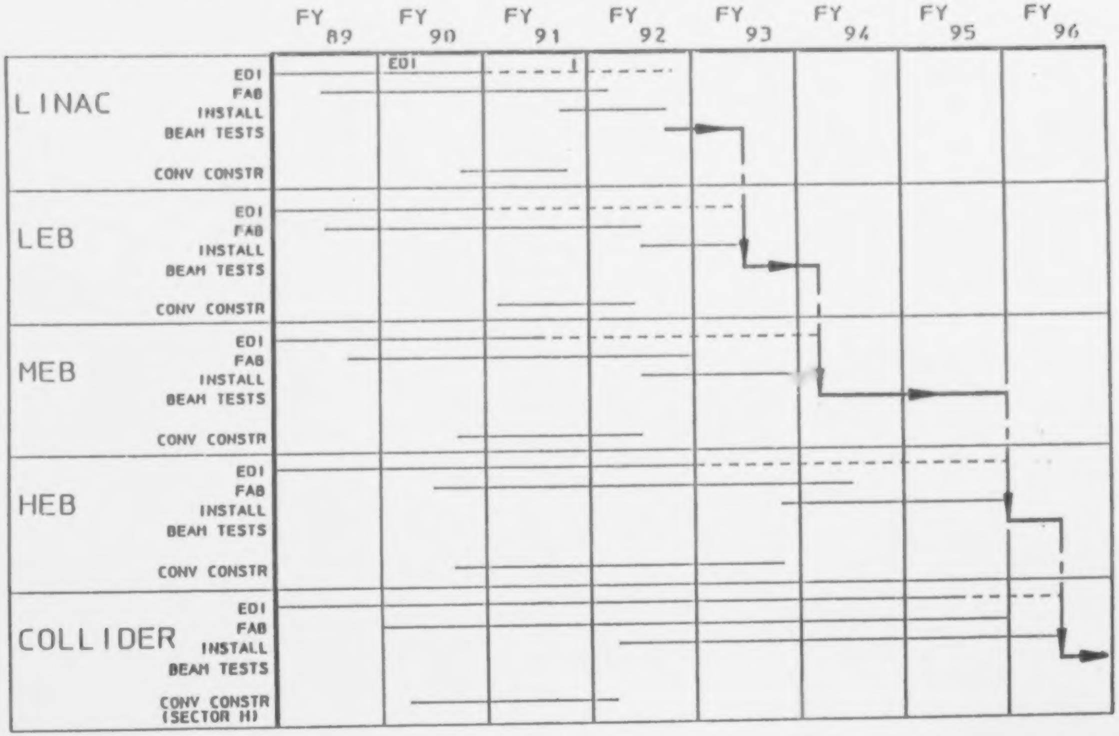
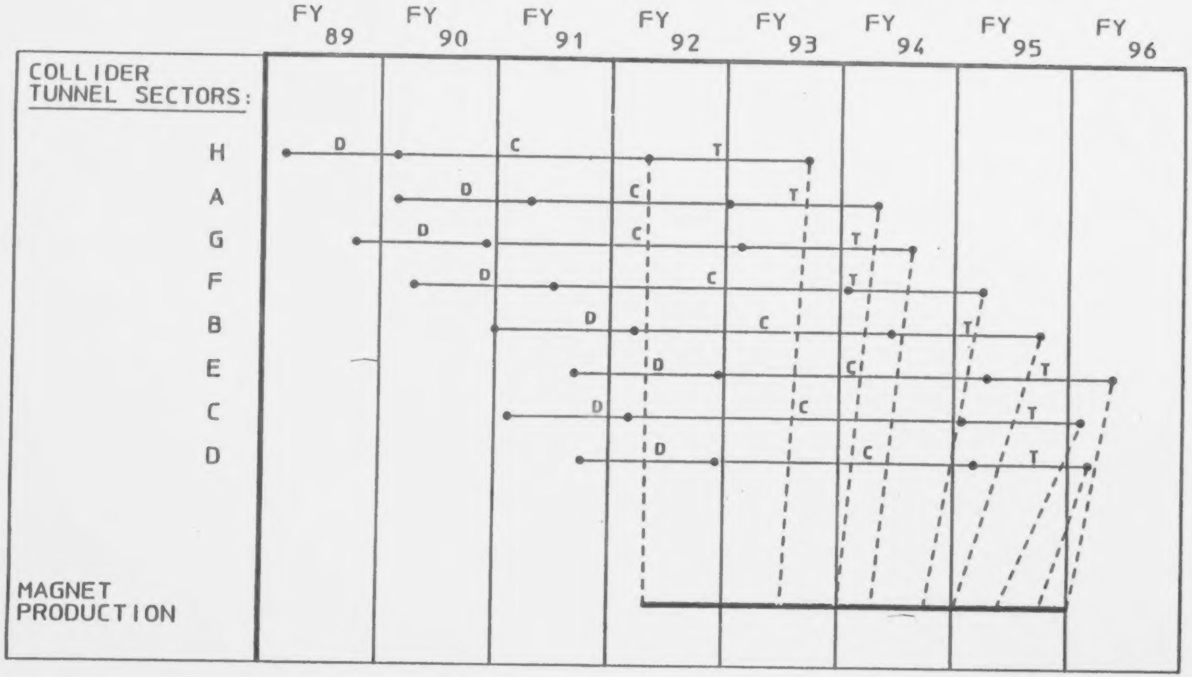


Figure 6

SSC COLLIDER TUNNEL SUMMARY SCHEDULE



D - DESIGN OF CONVENTIONAL SYSTEMS
C - CONSTRUCTION OF CONVENTIONAL SYSTEMS
T - TECHNICAL INSTALLATION OF MAGNET SYSTEMS

[illegible]

Figure 7

DISCUSSION

The CHAIRMAN. Thank you very much, Dr. Tigner. Let me ask you a question. We're debating the issue of how much we're going to fund here. Your talking about needing, according to the details on Page 17, your talking about needing $64 million for R&D for fiscal '89, right?

Dr. TIGNER. Yes, sir.

The CHAIRMAN. Of which $44 million would be for the superconducting magnet development?

Dr. TIGNER. Yes, sir.

The CHAIRMAN. Let me ask you, suppose as we asked before if you did receive the $64 million but lesser than that, where would you concentrate?

Dr. TIGNER. We would still concentrate on the superconducting magnets.

The CHAIRMAN. On the magnets? The magnets you consider as the heart of it any way?

Dr. TIGNER. That's the key technical system of the whole shebang.

The CHAIRMAN. So therefore, you're saying to carry out your level of work on the magnet development, that's your bottom line, it's $44 million for that?

Dr. TIGNER. That is what we understand to be absolutely essential to the technical progress of this project, yes, sir.

The CHAIRMAN. That's the point I'm trying to make. So, in other words anything lesser that $44 million or $45 million, the project comes a cropper at that point?

Dr. TIGNER. There would certainly be significant delays.

The CHAIRMAN. When you say significant, what do you mean? A year, two years, five years, three years?

Dr. TIGNER. Certainly, if the essential resources are not provided, then it's going to be delayed by a year until the essential resources are provided.

The CHAIRMAN. When you're saying the $44 million, let's suppose we were to give you the $44 million, hopefully, and the $44 million were available would you be able to be—your R&D could be concluded in that year's time do you think?

Dr. TIGNER. I showed you a road map for the program. We would certainly be able to carry out that part of the program that deals with magnets as shown here in FY '89. However, the SSC is an integrated facility which has lots of things to it, and in order to avoid delay in the completion of the overall facility, one needs to go forward at some rate with all of the necessary components.

The CHAIRMAN. That's what I'm trying to get at. So, in other words, we're saying that it's not just the magnets alone. Some of the other work, for example, the collider technical systems, the injector systems, all of this is part of the whole to make it work?

Dr. TIGNER. That's absolutely correct.

The CHAIRMAN. The Chair recognizes the distinguished gentleman from California.

Mr. NAGLE. I have no questions.

The CHAIRMAN. The gentleman from Iowa has no questions. You're getting off awfully easy, I would suggest that. Basically, that's our concern. In other words, I think you're telling us that if you had nothing else you could do you would do the $44 million as far as the superconducting magnets would be concerned; you can't say that that would set it back a year, could set it back three years, if you're not doing other parts of the work concurrently with that. Is that a fair comment?

Dr. TIGNER. Correct.

The CHAIRMAN. So therefore, the bare bones as far as the research and development projects are concerned, $64 million is your bottom line?

Dr. TIGNER. Yes, sir.

The CHAIRMAN. I have no further questions. I want to thank you. The gentleman from—

Mr. BROWN. Just so you won't think that I didn't try to ask some questions, I want to point out that Dr. Tigner's presentation is the most complete, clear and detailed of any of the presentations and I understand it completely, and therefore I don't need to ask any questions.

Dr. TIGNER. Thank you, sir.

The CHAIRMAN. I'm glad I gave up smoking those cigars. Does the gentleman from Iowa wish to comment?

Mr. NAGLE. Well, that does spur a comment that I think we ought to examine, what's in the cigar, Congressman Brown?

The CHAIRMAN. We want to thank you very much. You have given us an update, and we understand and appreciate your testimony very much.

Dr. TIGNER. Thank you, sir.

PANEL 3: INDUSTRY

The CHAIRMAN. The next and final group for this afternoon is Mr. R. A. Johnson, Assistant Director for Marketing for General Dynamics; Mr. Michael Davis, Martin Marietta Aerospace; and Dr. Harold Forsen, Senior Vice President, Manager of R&D, Bechtel Corporation.

We want to welcome you all and thank you for your patience and perseverance, but that's how the system works. First, I guess we would call upon Mr. Johnson, General Dynamics, you're first on my list.

I would suggest that all of your testimony for all three of our witnesses will appear in full on the record, you might want to use the time that's available to you to summarize and get the key points that you would like to get across.

So suppose we go first with Mr. Johnson.

STATEMENT OF R.A. (BOB) JOHNSON, MANAGER, ENERGY PROGRAMS, GENERAL DYNAMICS SPACE SYSTEMS DIVISION, SAN DIEGO, CA

Mr. JOHNSON. Thank you. Construction of the SSC will create an infrastructure that will enable our country to capitalize on the potential of superconductivity. At General Dynamics, Energy Programs Group, we are particularly interested in the development and application of superconducting magnets.

We see the SSC as a means to realize that potential. Superconductivity is expected to generate a market for superconducting products of over $10 billion by the year 2000.

The CHAIRMAN. Why don't you stop there.

Mr. JOHNSON. All right.

The CHAIRMAN. You're making a very important statement. You know, we've been listening to everybody, all the negatives around here for half the day, and you're saying that the work as industry sees it, if I hear you correctly, where the magnets are involved and superconducting magnets we're taking a quantum step forward in technology at that point?

Mr. JOHNSON. Yes, sir. The number, however, of $10 billion includes low-temperature superconductivity and the more recently discovered high-temperature superconductivity and this number is generally the one that is touted nowadays by the venture capitalists.

The CHAIRMAN. But I think what's important to get into the record that you're saying by moving ahead now, if I'm hearing you correctly and paraphrasing, by moving ahead now, we are taking a quantum step from a technological point of view of improving our knowledge in this field?

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. And therefore, it's not just for the Superconductor Super Collider that we're doing this; we're doing this so far as our knowledge and ability, as far as the magnets are concerned and other adaptations, is that correct?

Mr. JOHNSON. That is correct.

The CHAIRMAN. Proceed.

Mr. JOHNSON. The most challenging technical components to be developed for the main ring of the SSC are the superconducting dipole magnets. These large superconducting magnets steer the proton beams in circular arcs required by the 53 mile circumference of the SSC.

The Central Design Group in the National Laboratories have clearly recognized that these components were the most challenging and since 1983 have devoted much of their technical resources to the development of these magnets.

To date, they have built approximately 20 short magnets, up to four and a half meters long, and four full-length magnets, 16.7 meters long.

Three more full-length magnets are in the final stages of fabrication and test. It is our understanding that very close to full operational magnetic field strength has been achieved in two of the full-length prototype magnets.

However, reaching this performance level required several training charge cycles for economic viability and production, the number of training cycles must be reduced or preferably eliminated.

The ultimate requirement to manufacture high-quality and reliable SSC magnets is to assure that these characteristics are intrinsic and that development design prior to committing the product to manufacture.

In other words, quality must be designed into the product; it can not be added later. Industry accomplishes this goal by including the technical expertise of manufacturing, quality, producability and reliability engineering during the development process.

In our opinion, the National Laboratories are not staffed with as many engineers as that are required for SSC. We believe that minimal engineering involvement during the development design and fabrication of prototype components compromises the ultimate quality, reliability and producability of all highly-technical products, particularly those which are to be produced in large quantities.

Laboratory techniques are excellent for experimental devices or very small quantity production. Industry has the expertise to take highly-complex developmental concepts and produce very reliable quality products in large volumes.

To obtain quality products, there first must be organization for quality. Quality assurance standards such as the nuclear standards established by the American National Standard Institute, ANCI, or the American Society of Mechanical Engineers, ASME, do not exist for superconducting magnets.

Typically, major DOE programs specify ANCI and ASME nuclear quality assurance standards, we think that guidelines provided in these standards would be quite applicable in development a quality assurance plan for the SSC magnet program.

We recommend industrial involvement in the quality, reliability and producability engineering aspects during the critical prototype development phase.

Additionally, an SSC laboratory quality assurance program which includes control of equipment and materials, acquisition and recording of data, peer reviews, audits, design reviews, and inspections should be instituted.

We recommend involving U.S. industry as early as possible to support the magnet development program. Engineering skills, including electromagnetic analysis, structural analysis, thermodynamic analysis, test integration, manufacturing and producability, as well as quality assurance, are needed now.

U.S. industries have extensive skills in these key areas. There are several ways in which these engineering skills in industry can be immediately applied.

One approach would be for the SSC Central Design Group to involve experienced industrial superconducting magnet experts in workshops where magnet development status is presented along with any problems and associated plans for corrective action.

Also, increased involvement of magnet experts in industry to perform analytical studies, in particular critical areas is warranted. In our opinion, this type of collaboration is the most effective form of technology transfer in both directions.

Of course, this type of activity is already being done to some degree, but needs to be expanded and accelerated. Regarding the U.S. industrial base to support production of SSC magnets, several U.S. firms have produced a large number of superconducting magnets over the past decade.

General Dynamics has produced 29 superconducting magnets since 1976, representing about 65 percent of the available DOE market.

In so doing, General Dynamics has developed a highly skilled team, well versed in all aspects of the design analysis and fabrication disciplines.

Selected U.S. industrial firms are well positioned to participate in the final engineering design and fabrication of the SSC magnet system. Capacity to build large superconducting magnets has been demonstrated.

General Dynamics operated four winding lines simultaneously producing superconducting magnets for the MFTF-B fusion program. We met a schedule almost as challenging as that for the SSC.

The SSC magnet production rate is high compared to any previous superconducting magnet program. However, it is not unusual when compared to other high-technology equipment. As an example of available U.S. manufacturing capacity, the total factory space required to assemble all 7,620 superconducting dipole magnets is only one percent of the total factory space available within General Dynamics alone.

Other companies have developed similar capabilities. Superconducting magnets for magnet resonance imaging are routinely being produced in this country, although these magnets are much smaller than those which we fabricated several 100 are presently produced each year.

The capacity for production of the materials for the SSC magnets has been explored and found to be available in this country. General Dynamics has, with the assistance of over 40 potential subcontractors, performed magnet cost studies over the past three years.

As part of these studies, we verified capacity for materials where the SSC requirements appeared to strain the U.S. annual production rates.

The superconducting cable is probably the single most critical material procurement for the SSC magnets. The program will require on the order of $50 million per year of this material for about five years.

Although this quantity of superconductors represents more than double the present U.S. production of superconducting cable, it appears that there is adequate reserve production capacity to meet this demand.

This will require a modest expansion of wire drawing and cabling capacity. We feel that the superconducting magnet component producers in the United States are capable of meeting their requirements for the SSC, if early industrial involvement is planned and provision for long-lead procurement is authorized.

In our opinion, American industry is well positioned and anxious to meet the requirements of the SSC magnet program. Experience gained by our company and others over the past 12 years has prepared us for an active and early participation in the final development of superconducting magnets for SSC.

Work on other superconducting magnet programs has fostered a strong U.S. industrial base which can make a significant contribution to the SSC project.

Innovative design, analytical and fabrication techniques have been developed on other programs which should be shared with the Laboratories in the industrialization of the SSC magnets.

The blend of the scientific expertise at the Laboratories and high-production capabilities and experience of industry should be optimized to provide for efficient, economical and high-quality fabrication of the SSC magnets.

General Dynamics feels that this can best be achieved by involvement of industry during the final iterations of the magnet design.

We feel that the capability and capacity available in American industry should be used to the maximum extent to assure the success of this important program.

In summary, I believe that U.S. industry is ready to help, eager to do so, and the time to proceed is now.

Thank you.

[The prepared statement of Mr. R.A. Johnson follows:]

Statement of

GENERAL DYNAMICS

before the

U.S. House of Representatives Committee on Science, Space and Technology

by

R.A. (Bob) Johnson
Manager, Energy Programs

GENERAL DYNAMICS
Space Systems Division

22 March 1988

Statement of General Dynamics 22 March 1988

Chairman Roe and distinguished members of this committee, General Dynamics is pleased to have the opportunity to present to you our views on the Superconducting Super Collider (SSC) magnet development program. We think that the SSC must be built. A world-class facility such as this will surely re-kindle scientific pre-eminence and competitiveness in the United States.

Reflecting on achievements from other accelerator facilities, many quite marvelous developments have occurred that are beginning to have a truly remarkable influence on the quality of each of our lives. By building SSC, it is envisioned that other significant technological developments will surface. Some achievements from current accelerator facilities include:

- Proton Beam Therapy - A successful, non-invasive treatment of cancerous tumors of the eye, head, neck, and spinal cord.
- Ion Implantation - A surface treatment technique that produces artificial hip joints exhibiting wear characteristics over 400 times greater than by present technology.
- X-ray Lithography - A process that produces faster, more powerful computer chips capable of holding over 1 billion circuits -- a thousand-fold increase in power over current chips.

Surely even greater technological spinoffs will emerge from the SSC.

Perhaps equally as important as the scientific merits, construction of the SSC will create an infrastructure that will enable our country to capitalize on the potential of superconductivity. At General Dynamics -- Energy Programs group -- we are particularly interested in the development and application of superconducting magnets. We see the SSC as a means to realize that potential. Superconductivity is expected to generate a market for superconducting products of over $10 billion by the year 2000.

Key areas of the DoE magnet development program include the development and fabrication challenges which the program faces, and the ultimate reliability and quality assurance needs associated with the manufacture of over 10,000 superconducting magnets for the SSC. Also, in accordance with your invitation to testify today, I shall describe the U.S. industrial base for supporting the magnet development and production phases.

Development and Fabrication Challenges which the Program Faces

The most challenging technical components to be developed for the main ring of the SSC are the superconducting dipole magnets. There are 7,620 of these magnets required. These large superconducting magnets steer the proton beams in circular arcs required by the 53-mile circumference of SSC. The Central Design Group and the national laboratories have clearly recognized that these components were the most challenging and since 1983 have devoted much of their technical resources to the development of these magnets. To date, they have built approximately 20 short (up to 4.5 meters long) magnets and four full-length (16.7 meters long). Three more full-length magnets are in final stages of fabrication and test.

It is our understanding that very close to full operational magnetic field strength has been achieved in two of the full-length prototype magnets. However, reaching this performance level required several "training" charge cycles. For economic viability in production, the number of training cycles must be reduced or preferably eliminated.

Ultimate Reliability and Quality Assurance Needs Associated with Manufacturing SSC Magnets

The ultimate requirement to manufacture high quality and reliable SSC magnets is to assure that these characteristics are intrinsic in the development design prior to committing the product to manufacture. In other words, quality must be designed into the product; it cannot be added later. Industry accomplishes this goal by including the technical expertise of manufacturing, quality, producibility, and reliability engineering during the development process.

In our opinion, the national laboratories are not staffed with as many engineers as are required for SSC. We believe that minimal engineering involvement during the development, design, and fabrication of prototype components compromises the ultimate quality, reliability, and producibility of all highly technical products, particularly those which are to be produced in large quantities.

Laboratory techniques are excellent for experimental devices or very small quantity production. Industry has the expertise to take highly complex developmental concepts and produce very reliable, quality products in large volumes. To obtain quality products, there first must be organization for quality.

Quality assurance standards, such as the nuclear standards established by the American National Standard Institute (ANSI) or the American Society of Mechanical Engineers (ASME), do not exist for superconducting magnets. Typically, major DoE programs specify ANSI/ASME Nuclear Quality Assurance standards. We think that guidelines provided in this standard would be quite applicable in developing a quality assurance plan for the SSC magnet program.

We recommend industrial involvement in the quality, reliability, and producibility engineering aspects during the critical prototype development phase. Additionally, an SSC laboratory quality assurance program which includes control of equipment and materials, acquisition and recording of data, peer review, audits, design reviews, and inspection should be instituted.

U.S. Industrial Base for Supporting the Magnet Development

We recommend involving U.S. industry as early as possible to support the magnet development program. Engineering skills, including electromagnetic analysis, structural analysis, thermodynamic analysis, test integration, manufacturing/ producibility, as well as quality assurance are needed now. U.S. industries have extensive skills in these key areas.

There are several ways in which these engineering skills in industry can be immediately applied. One approach would be for the SSC Central Design Group to involve experienced industrial superconducting magnet experts in workshops where magnet development status is presented along with any problems and associated plans for corrective action. Also, increased involvement of magnet experts in industry to perform analytical studies in particular critical areas is warranted. In our opinion, this type of collaboration is the most effective form of technology transfer. Of course, this type of activity is already being done to some degree but needs to be both expanded and accelerated.

U.S. Industrial Base to Support Production of the Magnets for SSC

Regarding the U.S. industrial base to support production of the SSC magnets, several U.S. firms have produced a number of large superconducting magnets over the past decade. General Dynamics has produced 29 large (multi-ton) superconducting magnets since 1976, representing about 65% of the available DoE market. In so doing, General Dynamics has developed a highly skilled team, well versed in all aspects of the design, analysis, and fabrication disciplines. Selected U.S. industrial firms are well positioned to participate in the final engineering design and fabrication of the SSC magnet system. Capacity to build large superconducting magnets has been demonstrated. General Dynamics operated four winding lines simultaneously, producing superconducting magnets weighing several tons each for the Mirror Fusion Test Facility-B (MFTF-B) fusion program. We met a schedule almost as challenging as that for SSC. The SSC magnet production rate is high compared to any previous superconducting magnet program. However, it is not unusual when compared to other high technology equipment. As an example of available U.S. manufacturing capacity, the total factory space required to assemble all 7,620 superconducting dipole magnets is only one percent of the total factory space available within General Dynamics alone.

Other companies have developed similar capabilities. Superconducting magnets for magnetic resonance imaging (MRI) are routinely being produced in this country. Although these magnets are much smaller than those which we fabricated, several hundred are presently produced each year. The capacity for production of the materials for the SSC magnets has been explored and found to be available in this country. General Dynamics has, with the assistance of over 40 potential subcontractors, performed magnet cost studies over the past three years. As part of these studies, we verified capacity for materials where the SSC requirements appeared to strain the U.S. annual production rates. The superconducting cable is probably the single most critical material procurement for the SSC magnets. The program will require on the order of $50M per year of this material for about five years. Although this quantity of superconductors represents more than double the present U.S. production of superconducting cable, it appears that there is adequate reserve production capacity to meet this demand. This will require a modest expansion of wire-drawing and cabling capacity. We feel that the superconducting magnet component producers in the United States are capable of meeting the requirements for the SSC if early industrial involvement is planned and provision for long-lead procurement is authorized.

In our opinion, American industry is well positioned and anxious to meet the requirements of the SSC magnet program. Experience gained by our company and others over the last 12 years has prepared us for an active and early participation in the final development of the superconducting magnets for SSC. Work on other superconducting magnet programs has fostered a strong U.S industrial base which can make a significant contribution to the SSC project. Innovative design, analytical, and fabrication techniques have been developed on other programs which should be shared with the laboratories in the industrialization of the SSC magnets. The blend of the scientific expertise at the laboratories and high-production capabilities and experience of industry should be optimized to provide for efficient, economical, and high quality fabrication of the SSC magnets. General Dynamics feels that this can best be achieved by involvement of industry during the final iterations of the magnet design. We feel that the capability and the capacity available in American industry should be used to the maximum extent to ensure the success of this important program.

In summary, I believe that U. S. industry is ready to help, eager to do so, and the time to proceed is now.

I would like to thank Chairman Roe and the members of this committee for providing General Dynamics the opportunity to appear before you today and express our views on the Superconducting Super Collider. We commend the committee for conducting a hearing on SSC -- an extremely important program for the future competitiveness of the United States. Further, we praise the committee's commitment to its important work related to science, space, and technology.

We ask for your support in making the SSC a reality.

The CHAIRMAN. Mr. Davis.

STATEMENT OF MICHAEL DAVIS, DIRECTOR, SSC PROGRAM, MARTIN MARIETTA ASTRONAUTICS, DENVER, CO

Mr. DAVIS. Thank you. I appreciate the opportunity to appear before this Committee and present our company's viewpoint on the Superconducting Super Collider program.

Martin Marietta is one of the major systems engineering contractors on large complex U.S. government projects and is very interested in the SSC.

I am Michael Davis, the Director of the SSC program in Martin Marietta Astronautics in Denver, Colorado. And, I am responsible for all our company's SSC related activities.

We believe that the Superconducting Super Collider will prove to be a major tool to the advancement of basic science. That it is feasible with today's technology. We'll require strong industry support and participation and the long-term benefits to American industry will be large.

The SSC is needed to advance our basic knowledge of the structure of matter, and without it the United States may lose its preeminent position in the field of particle physics, a position it has held since World War II.

We are impressed by the potential contributions technology spin off has been a constant feature of previous accelerator programs and the SSC will continue this heritage.

Over the last few months, a team of scientists and engineers at Martin Marietta Corporation, led by myself, has carefully studied the SSC design report and has visited high energy physics labs worldwide, including Fermilab, SLAC and CERN, in order to better understand the SSC.

We have seen firsthand that the construction of the SSC is within the state-of-the-art. The scale of the project, however, is such that a company like Martin Marietta, with our experience in large systems design, development and integration, can play an important role.

Martin Marietta has served as a systems integration support contractor on many large complex programs. One is the systems engineering and integration support to the Air Force on the new Space Shuttle launch site at Vandenberg Air Force Base in California.

Our work involved coordination of many simultaneous projects, varied groups and contractors.

We also developed lander and integrated all of the scientific experiments into the Viking mission to Mars.

Both of these programs required many tradeoffs and compromises to assure that mission goals, schedule and cost were achieved.

Another example is the work we are doing to assist the FAA in the modernization of the Nation's air traffic control system.

This massive program involves numerous contractors installing and operating equipment in traffic centers throughout the country while continuing to support the day to day operations of the air traffic control system.

The design and careful planning of this transition from old to new equipment has required the highest order of integration skills.

The role we visualize for Martin Marietta, is to assist the high energy physics community to successfully build the SSC. The top level design knowledge and much of the detailed sub-system and component knowledge, resides in the core group of accelerator physicists and engineers who have designed and built our present accelerators and have made the conceptual design of the SSC.

We believe that as an integrating industrial partner, we can supply many of the needed project management skills and disciplines. This will enable the scientists to apply their time and energy to the issues and problems that most need their attention.

This will be of particular importance during the early phases of the program where it is necessary to develop the consistent set of system requirements and program plans.

In conclusion, we at Martin Marietta support the construction of the SSC. It is necessary for the continuation of basic research in particle physics.

During calendar year 1988, there are many issues that need to be addressed. The selection of the preferred site; the formation of an SSC national laboratory; and the selection of the management and operations organization, and the laboratory director.

The design proposed by the Central Design Group is feasible and achievable. If we do not move promptly, the rest of the world stands ready to step into our shoes as the leader in this important area of basic research. We will all be proud of the SSC when it is built.

The science team which will assemble around it will be the finest in the world. We look forward to the opportunity to participate in this exciting and challenging project.

Thank you.

The CHAIRMAN. Dr. Forsen?

[The prepared statement of Mr. Davis follows:]

MARTIN MARIETTA SUPPORTS THE SSC PROGRAM

Testimony Before the
U.S. House of Representatives
Space, Science and Technology Subcommittee
March 22, 1988

By
Michael Davis
Martin Marietta Astronautics
Denver, Colorado

MARTIN MARIETTA SUPPORTS THE SSC PROGRAM

I appreciate the opportunity to appear before this committee and present our company's viewpoint on the Superconducting Super Collider Program. Martin Marietta is one of the major Systems Engineering contractors on large, complex U.S. Government projects and is very interested in the SSC.

I am Michael Davis, the Director of the SSC Program at Martin Marietta Astronautics in Denver Colorado, and am responsible for all our company's SSC related activities.

We believe that the Superconducting Super Collider will prove to be a major tool for the advancement of basic science; that it is feasible with today's technology; will require strong industry support and participation; and the long-term benefits to American industry will be large.

The SSC is needed to advance our basic knowledge of the structure of matter and without it the United States may lose its pre-eminent position in the field of particle physics, a position it has held since World War II. We are impressed by the potential contributions that the SSC would make to high-tech industry. Technology spinoff has been a constant feature of previous accelerator programs, and the SSC will continue this heritage.

(more)

Over the last few months, a team of scientists and engineers at Martin Marietta Corporation, led by myself, has carefully studied the SSC Design Report and has visited high energy physics labs worldwide, including Fermilab, SLAC and CERN in order to better understand the SSC. We have seen, firsthand, that construction of the SSC is within the state of the art.

The scale of the project, however, is such that a company like Martin Marietta, with our experience in large systems design, development and integration, can play an important role.

Martin Marietta has served as a Systems Integration Support contractor on many large, complex programs. One is the systems engineering and integration support to the Air Force on the new Space Shuttle launch site at Vandenberg Air Force base in California. Our work involved coordination of many simultaneous projects, varied groups and contractors. We also developed the lander and integrated all of the scientific experiments into the Viking mission to Mars. Both of these programs required many trade-offs and compromises to assure that mission goals, schedule and cost were achieved.

Another example is the work we are doing to assist the FAA in the modernization of the nation's air traffic control system. This massive program involves numerous contractors installing and operating equipment in traffic centers throughout the country, while continuing to support the day-to-day operations of the air traffic control system. The design and careful planning of this transition from old to new equipment has required the highest order of integration skills.

(more)

The role we visualize for Martin Marietta is to assist the high-energy physics community to successfully build the SSC. The top-level design knowledge, and much of the detailed subsystem and component knowledge, resides in the core group of accelerator physicists and engineers who have designed and built our present accelerators and have made the conceptual design of the SSC. We believe that as an integrating industrial partner we can supply many of the needed project management skills and disciplines. This will enable the scientists to apply their time and energy to the issues and problems that most need their attention. This will be of particular importance during the early phases of the program where it is necessary to develop a consistent set of system requirements and program plans.

In conclusion, we at Martin Marietta support the construction of the SSC. It is necessary for the continuation of basic research in particle physics. During calendar year 1988 there are many issues that need to be addressed: The selection of the preferred site; the formation of an SSC national laboratory; and the selection of the management and operations organisation and the laboratory director. The design, proposed by the Central Design Group, is feasible and achievable. If we do not move promptly, the rest of the world stands ready to step into our shoes as the leaders in this important area of basic research. We will all be proud of the SSC when it is built. The science team, which will assemble around it, will be the finest in the world. We look forward to the opportunity to participate in this exciting and challenging project. Thank you.

###

STATEMENT OF DR. HAROLD K. FORSEN, SENIOR VICE PRESIDENT, AND MANAGER, RESEARCH AND DEVELOPMENT, BECHTEL NATIONAL, INC, SAN FRANCISCO, CA

Dr. FORSEN. Thank you, Mr. Chairman. There are many questions concerning the SSC before you and there are even more variations to the answers.

To me the key questions are do we need it, is it a viable project, and then simply, should we do it.

The answer to the first question is probably the most difficult for society and, therefore, Congress to tackle because the components have little to promise us except that it will provide information.

This information in the hands of the experts leads to knowledge and ultimately to the understanding of the forces and structures of matter.

A machine of this size and energy is needed to probe these forces that develop the data. One could ask as to the value of this information, and here, of course, the argument can be made that modern society as we know it today, coupled with the standard of living we enjoy and the future our children anticipate, is predicated on knowledge and understanding.

Understanding molecules and atoms, and the nucleus, has led to the development of a large fraction of the nations G&P. Any listing would fill pages, but would include modern chemistry, high-power electronics, transistors and computer chips, lasers, nuclear medicine and power, medical diagnostics and treatment, and many, many more.

Beyond this, we have benefitted from many other contributions along the way on the list of applications. These include the training of scientists and engineers who become the future leaders, interpreters and developers of the science and technology.

They become the educators and the builders of future generations for our society, such that progress continues. Not only does knowledge flow from these people, but also from the hardware and instruments of their trade.

These too find applications that are broader than their specific original intent. Here again, a listing of devices that benefit man that contribute to GNP can be developed and includes accelerators for medical applications, photolithography, and radiation effects; fast pulse counting; diagnostics instrumentation; and, even computers.

It is not possible to list the applications, flow-down of information and knowledge, and people without also noting the national pride of achievement such progress generates.

The Nobel Prizes are a big part of this and without the experimental apparatus to carry out this research, we will not attract the talent of this area of science to permit us to compete as we have in the past.

Neither we'll be able to develop the applications which hopefully will result from the new knowledge gained from such experimental apparatus.

My answer to the question of do we need it is, "Yes." We need it for a whole host of reasons beyond what is said above about knowledge, science and applications.

We need it because it is controversial, it challenges our leadership, our commitment to the future, and out national pride.

If the United States, the most powerful economy in the world, with world leadership in its standard of living and an international player in world peace and commerce, can not undertake such an futuristic step for the international knowledge, then we abandon the leadership role we have always enjoyed.

The question as to whether the project is viable can best be answered by the experts who are currently designing the machine, but to the best of my knowledge, the design is conservative.

We are not attempting to build the most powerful magnets, the highest-rated accelerator, the most beam current or the highest-brightness machine. It will, of course, be a challenge to make and align the magnets, the control systems, and the diagnostics, but the biggest challenge seems to be the commitment of Congress to funding without unnecessarily hurting all the other important research going on in the country.

This is a one-time project. The type of which comes along once in a while, and a way must be found to make it happen. It has been far too common in the past 20 or so years to find ways to stop or slow down things that are important to us rather than make them go.

Finally, the question should be should we do it and here I can only say we should. Pages have been filled with commentary for and against, but for me the basic issue is leadership.

Here is a chance to regain it along with the national pride it brings. Perhaps "throw deep" is really the answer.

Thank you.

[The prepared statement of Dr. Forsen follows:]

TESTIMONY TO THE
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

MARCH 22, 1988

ON THE

SUPERCONDUCTING SUPERCOLLIDER

BY

DR. HAROLD K. FORSEN

SENIOR VICE PRESIDENT,

MANAGER, RESEARCH AND DEVELOPMENT

BECHTEL NATIONAL, INC.

SAN FRANCISCO

There are many questions concerning the SSC before you and there are even more variations on the answers. To me the key questions are:

1) Do we need it,

2) Is it a viable project, and then simply

3) Should we do it.

The answer to the first question is probably the most difficult for society and therefore Congress to tackle because the proponents have little to promise us except that it will provide information. This information in the hands of the experts leads to knowledge and ultimately to the understanding of the forces and structure of matter. A machine of this size and energy is needed to probe these forces to develop the data.

One could again ask as to the value of this information and here of course the argument can be made that modern society as we know it today, coupled with the standard of living we enjoy, and the future our children anticipate, is predicated on knowledge and understanding. Understanding molecules, atoms and the nucleus has led to the development of a large fraction of the nations GNP. Any listing would fill pages but would include modern chemistry, high power electronics, transistors and computer chips, lasers, nuclear medicine and power, medical diagnostics and treatment, and many many more.

Beyond this we have benefitted from many other contributions along the way to the listed applications. These include the training of scientists and engineers who become the future leaders, interpreters and developers of the science and technology. They become the educators and builders of future generations for our society such that progress continues. Not only does knowledge flow from these people but also the hardware and instruments of their trade. These too find applications that are broader than their specific original intent. Here again a listing of devices that benefit man and contribute to GNP can be developed and includes accelerators for medical applications, photolithography, and radiation effects; fast pulse counting; diagnostics; instrumentation; and even computers.

It is not possible to list the application~~s,~~ flow down of information and knowledge, and people without also noting the national pride of achievement such progress generates. The Nobel awards are but a part of this and without the experimental apparatus to carry out this research we will not attract the talent to this area of science to permit us to compete as we have in the past. Neither will we be as able to develop the applications which hopefully will result from the new knowledge gained from such experimental apparatus.

My answer to the question of do we need it is yes. We need it for a whole host of reasons beyond what is said above about knowledge, science and applications. We need it because it is controversial, it challenges our leadership, our commitment to the future and our national pride. If the United States, the most powerful economy in the world, with world leadership in its standard of living and an international player in world peace and commerce cannot undertake such an altruistic step for international knowledge, then we abandon a leadership role we have always enjoyed.

The question as to whether the project is viable can best be answered by the experts who are currently designing the machine but to the best of my knowledge the design is conservative. We are not attempting to build the most powerful magnets, the highest gradient accelerator, the most beam current or the highest brightness machine. It will be a challenge to make and align all the magnets, the control systems and the diagnostics but the biggest challenge seems to be the commitment of Congress to the funding without unnecessarily hurting all the other important research going on in the country. This is a one time project, the type of which comes along once in a while and a way must be found to make it happen. It has been far too common in the past twenty or so years to stop or slow down things that are important to society than to make them go.

Finally, the question as to should we do it and here I can only say, we should. Pages have been filled with commentary for and against but for me the basic issue is leadership. Here is a chance to regain it along with the national pride it brings. Perhaps "throw deep" is really the answer.

PANEL 3 DISCUSSION

The CHAIRMAN. We want to thank you all very much for your presentations. I think the substance of one key point you're making is that there should be a more active dynamic participation of industry at an earlier time.

Is that pretty much what I'm hearing? So that we're not just taking a demonstration project so as to speak and laboratory, and then applying the technology for production, we're saying lets integrate that at the beginning or at least someplace along the line early enough so it can achieve what we're trying to achieve with the least delay. Is that reasonable?

Mr. JOHNSON. Yes.

Mr. DAVIS. Yes.

The CHAIRMAN. Any questions? The gentleman from California?

Mr. BROWN. Mr. Chairman, I just wanted to explore one question with Mr. Johnson a little bit. I think you mentioned some large figure, $10 billion or so, as the market for superconducting magnets, both high and low temperature down the road some where. We're not quite ready to get into the high-temperature superconducting magnets, I presume, because the state of the research has not yet given us an adequate understanding of the materials.

The question I have is assuming that we go ahead with the present low-temperature superconducting magnets, in which we understand the electrical and constructural and other characteristics of the material adequately, will the technology advances which we are making on these have applications to the new family of materials for high-temperature superconducting magnets, which will involve a new class of materials with different characteristics for fabrication and so forth?

Can we make the argument that the advances we make on the SSC will give us a head start in the economical development of the next generation of high-temperature superconducting magnets?

Mr. JOHNSON. Clearly there is a great deal of synergism between all magnet programs to date, all superconducting magnet programs.

The synergism will not be quite as great, perhaps, when we go to the high temperature material, but we would expect many of the design philosophies that we are learning today and building on today would still carry forward to the high temperature material.

Mr. BROWN. Well, I want to understand that little bit better because there are some making the argument today that we ought to wait until we fully understand the high-temperature superconducting phenomenon and develop materials which can be drawn into wires and do all the rest of the things that are necessary.

And, of course, that means putting off the SSC for probably another ten years or more. But, I want to be able to make the point that the progress we're making here will have direct application to a whole broader range of applications for superconducting magnets using the high-temperature materials when we have gone through the necessary development phase on these things. And your statement is that we can expect some level of synergism which will be helpful in that regard.

Mr. **Johnson**. Yes, and I would go on to say that even though superconductivity was discovered a long time ago, most of the major advances have been made in the last 15 years and with very major advances made by the National Laboratories and the Central Design Group in just the last year and a half or two years on the SSC project.

Mr. **Brown**. But we're talking low-temperature superconductors.

Mr. **Johnson**. Low temperature. And we're not through learning about low temperature yet. And I think that, for example, the programs that we looked at 12 years ago when we began in this area, which were fusion, magnetohydrodynamics and isotope separation, we hadn't even dreamed about MRI. We hadn't dreamed much about the accelerator programs. And yet, those have come to be very major endeavors in the just the last few years, and I think that this will continue. In the next five years we'll find things that we aren't even dreaming about today.

Mr. **Brown**. But, this is going to be dwarfed if we get a workable high-temperature superconductivity. The applications will boggle the mind probably.

Mr. **Johnson**. Yes, I would accept that's true.

The **Chairman**. Are there any other further questions? We want to thank you very much. We do have some written questions we'd like to be able to submit to you if you'd be kind enough to respond to them when we send them out to you. I want to thank everybody for participating. Thank you for your patience very much. The Committee stands adjourned.

[Whereupon, at 5:50 p.m. the Committee recessed, to reconvene at the call of the Chair.]

APPENDIX I

STATEMENT OF

CONGRESSMAN CARL D. PURSELL

SUPERCONDUCTING SUPER COLLIDER AUTHORIZATION

MARCH 22, 1988

Thank you, Mr. Chairman for allowing me to submit my statement. I wish to commend the committee for holding a hearing on the proposed Superconducting Super Collider, and for receiving a broad range of input.

I come before your committee today with a couple of hats on - first as a member of the Energy & Water Development Subcommittee of Appropriations which oversees funding for the project, and second as a member of Congress whose state is being considered as a possible site for the SSC.

The Superconducting Super Collider will be a unique basic research tool for high energy physics, the science that studies the fundamental nature of matter and energy.

In high energy physics, the development of the super collider is the equivalent of putting a man on the moon.

The supercollider holds the potential for a new generation and a new revolution in science, education, technology and commerce. As you will undoubtedly hear from others more qualified in the technical aspects of the project, the proposed SSC would be a world-class addition to our scientific and research community - an addition unequalled in size, scope and potential.

But my main purpose in presenting this statement to you is to focus more on the legislative process.

Under our present budget constraints, some hard choices will have to be made. There is no doubt this will be a costly project, with estimates running in the billions of dollars. Rest assured I am just as concerned about the funding as you are.

However, you are the authorizing committee. Your role in conducting hearings today - and ultimately ruling on the question of authorization - is to assess the benefits and merits of this great project. Your job is to decide whether this project should be a priority for our nation and thus warrants authorization for funding.

My request of the committee is that you consider this project on its merits and not its projected price tag. Please avoid the temptation to allow the cost or site selection question to overshadow an objective decision about the need.

Obviously, as a member of the Michigan delegation, I would like to see the SSC built in my state. However, the decision of where the SSC will be built shouldn't factor in my support of the project - it's either needed or not needed, exclusive of location.

Likewise, the question of funding shouldn't be a factor in your decision. Authorization should be a determination of need.

As a member of the Appropriations subcommittee which oversees the funding of this project, I can assure you we will closely look at the question of funding. We will weigh the availability of funds - and make a determination based on the priority of the authorization.

I appreciate the fact that we must be careful that funds for this project are not taken from other research projects. And, as you may be aware, DOE is seeking international collaboration and cost-sharing with other countries. All of these factors will play in our decision.

It is important that you, the authorizing committee, produce an authorizing bill so that we on the appropriations committee can have your support of the project.

Again, Mr. Chairman, I commend your committee for undertaking this authorization. I think your work here today will assist all members of Congress in better understanding the need for the project - and ultimately to persuade their decision whether to support the project.

Thank you for the opportunity to share my thoughts with you today.

APPENDIX II

SITING THE SUPERCONDUCTING SUPER COLLIDER

Super Collider Site Evaluation Committee
National Academy of Sciences
and
National Academy of Engineering

NATIONAL ACADEMY PRESS
Washington, D.C. 1988

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance. The report was reviewed by a committee of the Governing Board.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Samuel O. Thier is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Frank Press and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

The report was sponsored by the Department of Energy under contract number DE-AC01-87-ER40355.

Available from:
Super Collider Site Evaluation Committee
National Research Council
2101 Constitution Avenue N.W.
Washington, D.C. 20418

Cover illustration: A computer reconstruction of an event observed in 1.8-TeV proton-antiproton collisions showing a section of the detector oriented perpendicular to the beam direction. The curved tracks give the trajectories of charged subatomic particles created in the collision. In this example, the detected particles cluster into two back-to-back "jets" that indicate that a very energetic billiard-ball-like collision took place.

Printed in the United States of America

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Preface

The National Academy of Sciences (NAS) and National Academy of Engineering (NAE) were asked by the Department of Energy (DOE) to undertake, on an exceptionally tight schedule, the monumental task of assisting the department in selecting a site for the proposed Superconducting Super Collider (SSC). A committee was appointed by the academies, and according to several news stories, about 750 pounds of proposals were sent to each committee volunteer. Although we have not, ourselves, weighed the proposals, we can verify the reasonableness of that estimate.

The Super Collider Site Evaluation Committee was charged with developing guiding principles for evaluating proposed sites, considering the relative advantages and disadvantages of various sites referred to it by DOE, and identifying an unranked list of best-qualified sites, giving particular attention to the technical requirements and such other factors—known in light of past experience with large science research laboratories—as would assure scientific productivity. The final selection of a site remains to be made by DOE, not by the academies, and will, of course, depend on considerations of concern to DOE, some of which may lie outside the areas of expertise represented by the academies.

It is important to keep in mind that the academies were asked to advise on desirable locations—those particularly promising for scientific productivity—for an SSC; they were not asked to evaluate the scientific feasibility, opportunities, or need for an SSC. It was, however, important for the committee to understand the nature of the SSC and the scientific expectations of the high-energy physics community in order to evaluate effectively what site-specific factors were likely to be important for efficient construction and scientifically productive operation of such a facility.

I am pleased to acknowledge the substantial contributions of many individuals, agencies, and organizations to this important effort and, on behalf of the academies, to thank them. First and foremost, I am indebted to the committee's volunteer members. Together we are grateful to our dedicated staff for their effective efforts in collecting and analyzing data, preparing drafts, and generally facilitating our work. Without their brilliant support, we could scarcely have completed this awesome assignment on schedule.

We are indebted to the U.S. Army Corps of Engineers for helping to analyze the strengths and weaknesses of the proposals in regard to real estate title and costs. We appreciate the assistance provided by special staff consultants, Jerry Okeson and Richard C. Armstrong, to committee members Edward Jefferson and LTG E.R. Heiberg, respectively, and the contributions of Don Deere, Jr., and James Gamble, who helped analyze the geology and tunneling aspects of the proposals. DOE staff graciously provided the information and resources we requested.

We appreciate the information and thoughtful comments provided by a number of colleagues who participated in subgroup meetings. Val Fitch, of Princeton University, offered a useful perspective on the site selection task at the committee's first meeting. Dan Lehman and Robert Selby, of DOE, and Tom Elioff and Mack Riddle, of RTK Associates, contributed to the July meeting of our Costs subgroup. Similarly, the August meeting of our Regional Resources subgroup benefited greatly from insights provided by Leon Lederman of the Fermi National Accelerator Laboratory, Wolfgang Panofsky of the Stanford Linear Accelerator Center, Louis Rosen of the Los Alamos Meson Physics Facility, Samuel Ting of Massachusetts Institute of Technology, and Paul van den Bout of the National Radio Astronomy Observatory, Socorro, New Mexico.

Finally, my colleagues and I want to recognize the effort expended by those who prepared the proposals we evaluated and the high quality of the result of that effort. Although we were charged with identifying a short list of best-qualified sites, many—indeed most—of the proposals were impressive; in general they were thorough, informative, and complete. It is reassuring that so many proposing organizations should have shown so much vision, competence, and commitment to excellence.

Edward A. Frieman
Chairman, Super Collider
Site Evaluation Committee

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Executive Summary

At the request of the Department of Energy, the National Academy of Sciences and the National Academy of Engineering established the Super Collider Site Evaluation Committee to evaluate the suitability of proposed sites for the Superconducting Super Collider.

Thirty-six proposals were examined by the committee. (One of these was withdrawn from consideration during the course of the committee's evaluation.) Using the set of criteria announced by DOE in its *Invitation for Site Proposals*, the committee identified eight sites that merited inclusion on a "best qualified list." The list represents the best collective judgment of 21 individuals, carefully chosen for their expertise and impartiality, after a detailed assessment of the proposals using 19 technical subcriteria and DOE's life cycle cost estimates. The sites, in alphabetical order, are:

Arizona/Maricopa
Colorado
Illinois
Michigan/Stockbridge
New York/Rochester
North Carolina
Tennessee
Texas/Dallas-Fort Worth

1

Introduction

In 1965, the National Academy of Sciences assisted the Atomic Energy Commission in choosing a site for the 200-BeV accelerator laboratory that is now known as the Fermi National Accelerator Laboratory, and now houses the Tevatron, a 1-TeV accelerator (2-TeV proton-antiproton collider) that is currently the world's highest-energy machine. It can be viewed, then, as a continuing development in that vein that the National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) were asked again to assist in selecting a site for a newly planned high-energy physics facility, the Superconducting Super Collider (SSC).

The process was initiated in 1984 by identical letters to the presidents of NAS and NAE from Alvin Trivelpiece, the then director of the Office of Energy Research (OER) of the Department of Energy (DOE):

> [DOE] is sponsoring a program of research and development on the design of a future accelerator facility, the Superconducting Super Collider. . . . Although the Department has not yet made a decision to proceed with the project, the process by which site selection for this facility would occur needs to be established now. . . . [T]he Department would like to enlist the aid of the NAS and NAE in the site selection process. Specifically, we would like the Presidents of the two Academies to jointly select a review panel of about 15 distinguished individuals with appropriate experience . . . to evaluate qualified proposals against the site criteria requirements . . . [and] select a small group of those proposals that

> they believe to be most excellent in every respect. . . . [The Academies would] then inform the Director of OER as to which proposals had been selected to be in this group together with the Panel's summary of the basis for selection. . . . [Although] the specific number of proposals . . . in this final unranked list cannot [now] be foreseen, it is expected that only a few of the most qualified would be included. . . . It is essential that all institutions or organizations that compete for it be certain that they will receive fair and equitable treatment in all phases of an orderly selection process. . . . I am confident that the Academies' participation would provide a review of the proposals that meets the highest standards.

The presidents promptly agreed that if DOE made a decision to proceed with such a facility and asked the academies to assist, they would be prepared to do so in the manner outlined.

A January 30, 1987, announcement by the Secretary of Energy, John S. Herrington, that President Reagan had approved construction of the SSC was followed on February 10 by the announcement of a schedule for submission and evaluation of proposals and by a request to the academies to assist DOE in its evaluation. DOE asked the academies to evaluate qualified site proposals and to recommend an unranked best qualified list of sites by the end of 1987. DOE would then designate a preferred site in July 1988, and in January 1989 the Secretary of Energy would announce the final site. DOE modified this schedule in July in response to newly enacted legislation limiting allowable financial offers from proposers. Proposals became due in September, and the academies' report was to be delayed until early January 1988.

The academies and DOE agreed on a "work statement" (see Appendix A), and the presidents of the academies appointed a committee of experts (see Appendix E) in June, including specialists in high-energy physics, engineering geology, accelerator design, economics, procurement, the environment, large construction, and large-facility management. The committee's charge, as approved by the Governing Board of the National Research Council, noted that the evaluation, to be developed in light of past experience with large science research laboratories, would stress those items that were likely to be most critical in determining scientific productivity of the SSC laboratory. The charge also explicitly recognized that the final site selection was not to be made by the academies or the National Research Council; it was to be made by DOE and to be dependent upon considerations of concern to DOE, some of which might lie outside the areas of expertise represented by the academies.

2

The Superconducting Super Collider

The NAS and the NAE were asked to assess site proposals for a Superconducting Super Collider (SSC), particularly in light of how a given site might enhance the scientific productivity of the laboratory, and to develop a list of best-qualified sites. The academies were not asked to evaluate the scientific merit, opportunities, or need for an SSC. The focus of the academies' activities was on the site-specific effects that might affect the construction and productive operation of a super collider.

Much has been written elsewhere about the scientific promise of the SSC; the interested reader can find discussion of the science in the following publications:

1. Committee on Science, Engineering, and Public Policy, *Report of the Research Briefing Panel on Scientific Opportunities and the Super Collider*, National Academy Press, 1985.
2. J.W. Cronin, "The Case for the Super Collider," *Bulletin of the Atomic Scientists*, May 1986, pp. 8-11.
3. J.D. Jackson, M. Tigner, S. Wojcicki, "The Superconducting Supercollider," *Scientific American*, Vol. 254, No. 3, March 1986, pp. 66-77.
4. L.M. Lederman, "To Understand the Universe," *Issues in Science and Technology*, Vol. I, No. 4, 1985, pp. 55-65.

5. C. Quigg, R. Schwitters, "Elementary Particle Physics and the Superconducting Super Collider," *Science*, Vol. 231, March 28, 1986, pp. 1522-1527.

6. R.F. Schwitters, "Super Collider," *American Politics*, July 1986, pp. 5-7.

THE SSC AS A SCIENTIFIC INSTRUMENT

The SSC will have two counterrotating, tightly focused streams of protons guided along nearly circular orbits by superconducting magnets (see Figure 1). The protons in each beam will be accelerated to 20 trillion electron volts (TeV),* and the two beams will be brought into collision at several interaction regions around the circumference of the accelerator, yielding at those points a total useful energy of 40 TeV. The energy available for creating new particles of interest at the collision points of the SSC will be 200 times the energy that would be available if only one such beam were directed at a fixed target (see Figure 2).

The events resulting from collisions of interest will be complicated, with hundreds of particles flying out from the collision point. These particles must be tracked and measured to reconstruct the underlying physics responsible for the event. One particular challenge to SSC experimenters will be the high rate of collisions—about 100 million per second—of which only a tiny fraction will provide the scientists with new information of interest in specific investigations.

Sophisticated detectors of enormous size (see Figure 3) will be installed at the collision points. These detectors employ tracking chambers, analyzing magnets, large calorimeters, and other devices to observe high-energy particles to provide information on the trajectories, energies, and identities of the particles in a proton-proton collision. In addition to the detection hardware, extensive and elaborate high-speed, sensitive electronics is required to register and interpret the large amount of data that results from each collision event. The data are screened by special-purpose, high-performance computers to select events of special interest and then archived for subsequent off-line analysis.

The very large scale and sophistication of the detectors are necessitated by the high energies of the particles to be detected and by the inherent complexity of the collision events of interest. Materials such

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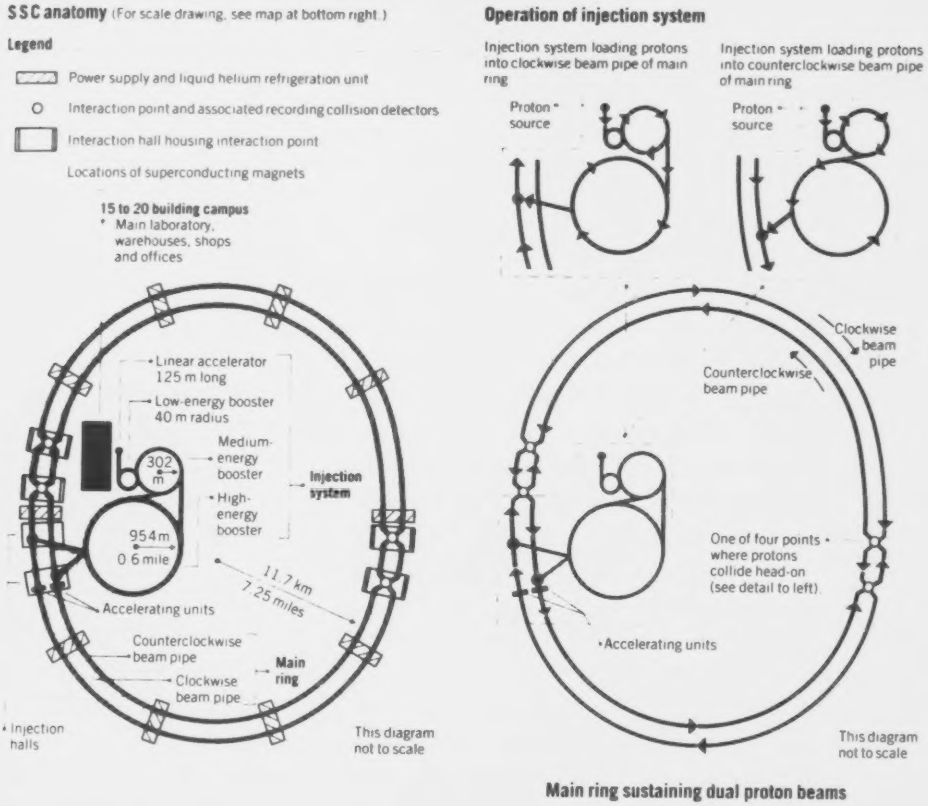
*An electron volt is a unit of energy equal to the energy given to each electron flowing through a circuit by a one-volt electrical battery.

The Superconducting Super Collider (SSC)


SSC anatomy (For scale drawing, see map at bottom right.)
Legend
Power supply and liquid helium refrigeration unit
Interaction point and associated recording collision detectors
Interaction hall housing interaction point
Locations of superconducting magnets
15 to 20 building campus
Main laboratory, warehouses, shops and offices
Linear accelerator 125 m long
Low-energy booster 40 m radius
302 m
Medium-energy booster
High-energy booster
Injection system
954 m 0 6 mile
11.7 km 7.25 miles
Accelerating units
Counterclockwise beam pipe
Clockwise beam pipe
Main ring
Injection halls
This diagram not to scale
Operation of injection system
Injection system loading protons into clockwise beam pipe of main ring
Injection system loading protons into counterclockwise beam pipe of main ring
Proton source
Proton source
Clockwise beam pipe
Counterclockwise beam pipe
One of four points where protons collide head-on (see detail to left)
Accelerating units
This diagram not to scale
Main ring sustaining dual proton beams

The size and power of the underground SSC would allow narrow beams of protons to collide at almost the speed of light, creating new subatomic particles observable only at very high energies that cannot be attained by existing accelerators. This diagram tracks the path of proton beams. Protons are produced by the ionization of hydrogen atoms.

The injection system (upper right), composed of a linear accelerator and three progressively larger circular energy boosters, prepares the protons for the main-ring collisions by accelerating them to higher and higher energies. Some protons are loaded into the clockwise beam pipe (green), then others into the counterclockwise one (black).

Inside the main ring (see central schematics), accelerating units speed the protons to 20 times their energy. The protons are guided in the high-energy booster and main ring by about 10,000 powerful superconducting magnets, refrigerated by liquid helium to 4.35° Kelvin (about −270° centigrade, −455° Fahrenheit). The magnets maintain the beams on their circular paths; special magnets near the interaction points force collisions between protons traveling in opposite directions. Detection apparatuses at each collision site will measure the energy released by the collisions and will trace the paths of particles produced by the collisions. By creating levels of energy similar to those of the "big bang," scientists hope to learn about the fundamental laws of nature that guided the creation of the universe.

Informational graphics: Michael Yanoff

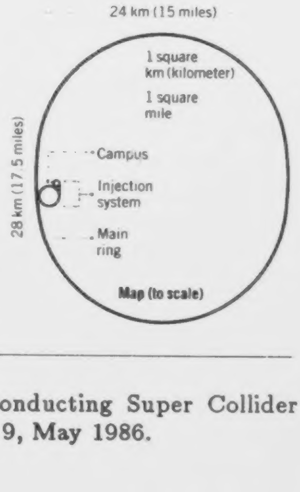

24 km (15 miles)
28 km (17.5 miles)
1 square km (kilometer)
1 square mile
Campus
Injection system
Main ring
Map (to scale)

FIGURE 1 A simplified description of the Superconducting Super Collider from the *Bulletin of Atomic Scientists*, volume 42, page 9, May 1986.

as iron and lead are used to absorb the energetic particles. Enough of these heavy materials must be used to assure that all of the particles produced are absorbed. Further, because particles are released in different directions, detectors must fully surround the collision point. The various requirements set the scale of the detectors, some of which may weigh as much as 40,000 tons.

Different kinds of detectors will be installed at different collision points in order to allow the investigation of a number of physics problems. Many crucial experimental tests have been proposed and formulated, and conceptual designs of various detectors have been prepared.

The detectors will generally require large-scale collaboration—including international cooperation—among many university and laboratory groups. Traditionally, such collaborations evolve from the common interests of experimental physicists, who unite in semipermanent scientific groups of students, postdoctoral researchers, and university professors supported by the engineering and technical staffs of laboratories and universities. The data collected by the detectors become available to all the collaborating members working in separate smaller groups according to their scientific interests.

The proposed accelerator scheme makes use, first, of a proton injector system that will accelerate protons to about 1 TeV, at which point the protons will be injected into the main SSC ring for the final acceleration phase. The injector will consist of a series of four separate accelerators: a linear accelerator about 500 feet long that will raise the protons from rest to an energy of 0.6 billion electron volts (GeV); a low-energy synchrotron booster about 820 feet in circumference, using conventional magnets, that will raise the protons to 7.0 GeV; a medium-energy ring about 1.2 miles in circumference, again using conventional magnets, that will raise the energy of the particles to 100 GeV; and a high-energy booster (HEB), some 4 miles in circumference, that will use superconducting magnets to increase the proton energies to 1 TeV.

The main ring will be located in a 53-mile-long race-track-shaped tunnel, 10 feet in cross-sectional diameter with its centerline at least 35 feet below the earth's surface. The tunnel will contain two evacuated tubes with proton beams moving in opposite directions and about 9500 powerful electromagnets—spaced along the beam lines—to keep the proton beams tightly focused in the evacuated tubes and constrained to closed, nearly circular orbits. (About 8000 bending (dipole) and about 1500 focusing (quadrupole) magnets will be used)

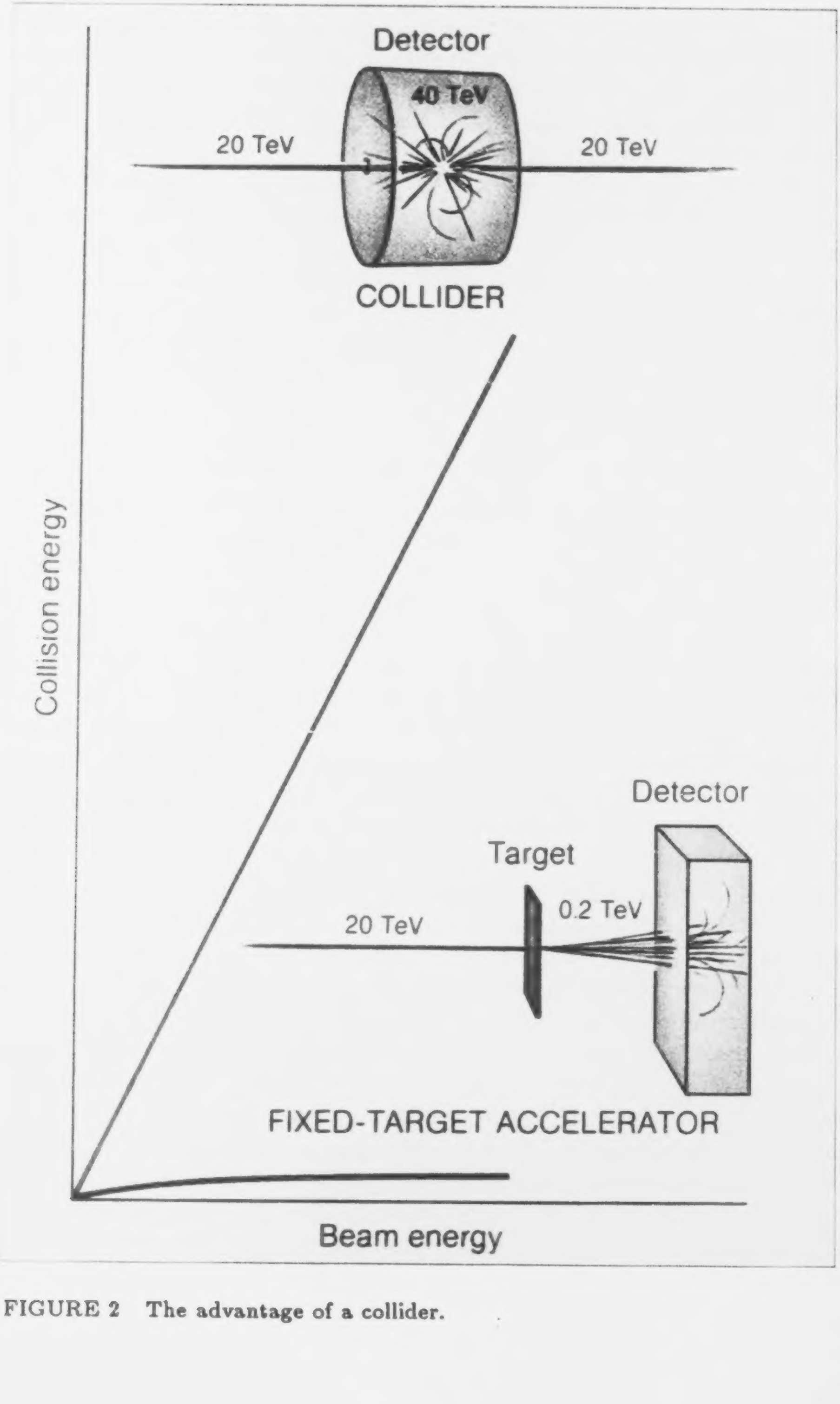

Detector
40 TeV
20 TeV
20 TeV
COLLIDER
Collision energy
Detector
Target
0.2 TeV
20 TeV
FIXED-TARGET ACCELERATOR
Beam energy

FIGURE 2 The advantage of a collider.

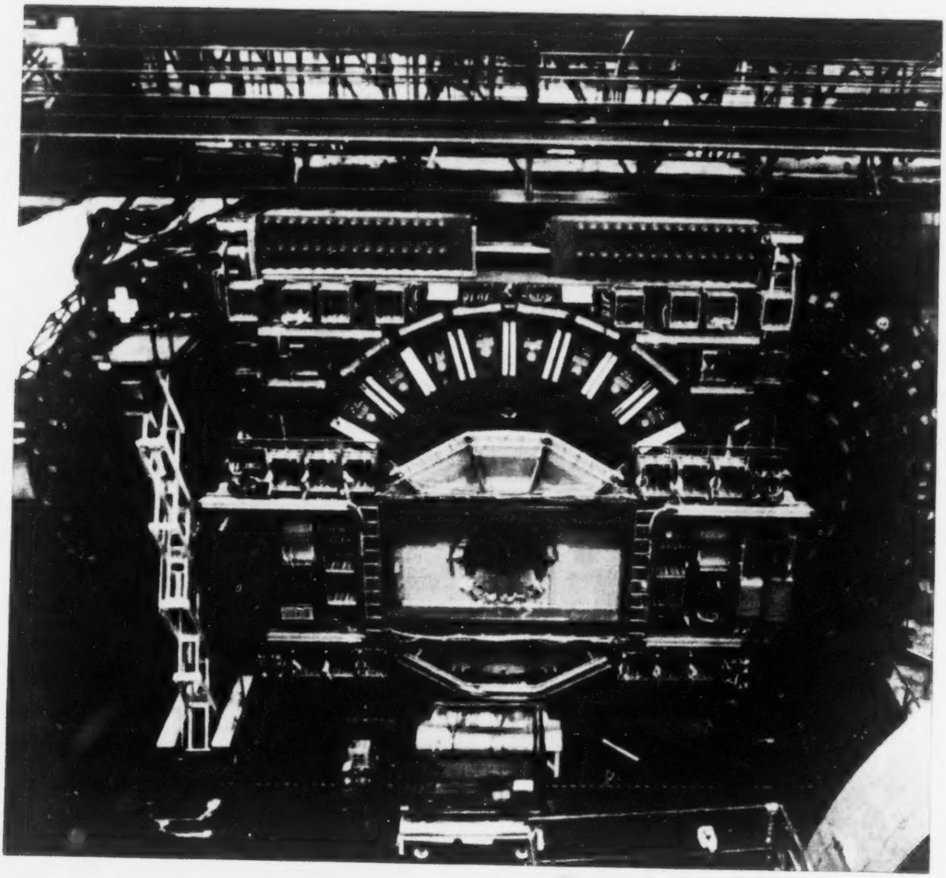


FIGURE 3 A collider detector during its assembly.

(see Figure 4). The ring will receive bunches of 1-TeV protons from the injector; the protons will be distributed around the ring and accelerated until they reach an energy of 20 TeV. When the protons are at the desired energy level, it will be possible to deflect the two beams so that they collide head-on with one another in the center of the particle detectors that surround the beams at the interaction points. After acceleration to full energy, the beams will continue to circulate for many hours while the experimental detectors record collision events. When the beam intensity falls, a new batch of protons will be introduced into the SSC and accelerated.

The main-ring bending and focusing magnets will use superconducting wire to carry the electric current that sets up the magnetic field. The costly and sophisticated superconducting cable as well as the great precision and quality control required in assembly will

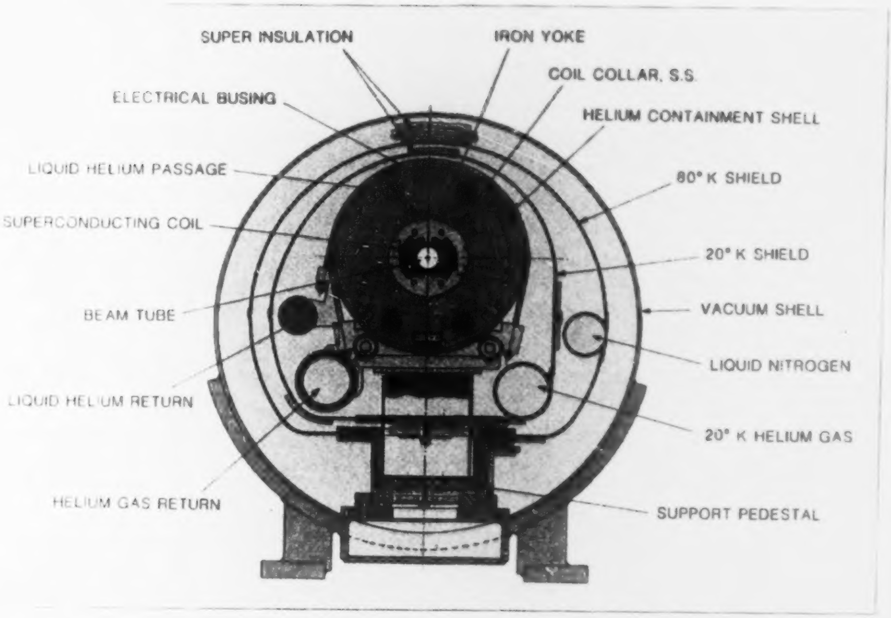

SUPER INSULATION
IRON YOKE
COIL COLLAR, S.S.
ELECTRICAL BUSING
HELIUM CONTAINMENT SHELL
LIQUID HELIUM PASSAGE
80° K SHIELD
SUPERCONDUCTING COIL
20° K SHIELD
BEAM TUBE
VACUUM SHELL
LIQUID NITROGEN
LIQUID HELIUM RETURN
20° K HELIUM GAS
HELIUM GAS RETURN
SUPPORT PEDESTAL

FIGURE 4 **Detail of magnet assembly.**

make the magnets expensive to build, although they will be relatively inexpensive to operate, because the superconducting coils have essentially no electrical resistance. In principle, a 20-TeV accelerator (of considerably larger circumference) could be built with conventional copper conductor electromagnets, but, because of the resistance of the wire, it would consume at least 4000 MW of power (as opposed to a total of 100 MW to be consumed by the entire SSC complex, much of which is necessary to cool the superconducting magnets to their required operating temperature) and lead to impractically high operating costs. Using superconducting magnets will reduce the total power consumption of the magnetic confinement system and permit the creation of magnetic fields several times stronger than any that could be achieved with conventional electromagnets. A stronger magnetic field will make it possible to confine protons of a given energy (say, 20 TeV) to an orbit of smaller radius and thus reduce the required length of the accelerator tunnel. The design circumference of the SSC—53 miles—is determined by the maximum intensity of its magnetic field—6.6 tesla—and the maximum energy of the protons—20 TeV.

The accelerator will also require hundreds of miles of cryogenic plumbing (at the boiling point of liquid helium, 4 K) to establish superconductivity. Such systems (though with a lower magnetic field) have been successfully constructed and used on a large scale in the Tevatron ring of the Fermi National Accelerator Laboratory, but the SSC cryogenic system will be some 13 times larger in scale than anything ever attempted.

THE SSC AS A CIVIL WORKS PROJECT

The proposed SSC will be the largest scientific instrument ever made. The tunnel, which will be the largest component of the facility, will be out of sight and covered by at least 35 feet of earth to ensure that no significant radiation ever reaches the surface. Approximately every 5 miles along the 53-mile tunnel, a cluster of surface buildings—housing cryogenic refrigerators, helium compressors, power supplies, and support facilities, and providing points of access—will be visible. Additional shafts allowing access to the collider tunnel will be located midway between adjacent service areas.

The campus—a focal point of the site—will be a science research center large enough to accommodate a staff of 3000, with a central office building, an auditorium, and various laboratory, support, and industrial buildings.

The SSC will consist of five major components: (1) an underground injector complex of cascaded accelerators to accelerate protons from rest to 1 TeV; (2) a main collider ring to accelerate, focus, and guide two beams of protons in opposite directions around the tunnel until they each reach an energy of 20 TeV, and then to "store" them in the ring until they are depleted through collisions; (3) collision/experimental areas containing the particle detectors; (4) campus/laboratory areas; and (5) a site infrastructure of roads and utilities.

The experimental areas containing the massive particle detectors will be located in two regions clustered diametrically opposite each other on the circumference of the collider ring. Each experimental area will have surface structures and underground collision and access halls. The dimensions of the collision halls will vary to allow a spectrum of possible experimental apparatus. The largest collision halls could be up to 160 feet long, 120 feet wide, and 130 feet high. Because the outside parts of the detectors are very likely to include large assemblies of thick steel plates—making the individual detector components enormously heavy—a thick concrete floor with steel plate capable of supporting loads of up to 9 tons/ft^2 will be used in the halls.

The campus area may have 15 or more buildings clustered in four major groups—a central laboratory building and auditorium, industrial buildings, warehouses, and auxiliary support buildings. The central laboratory building will provide office and laboratory space for administrative and technical personnel. One building might contain all the major offices of the facility and light laboratories for the development and testing of electronic components. Industrial buildings will house limited component assembly activities, various workshops, and associated offices. Warehouses will serve as receiving and storage facilities. The auxiliary support buildings—fire, rescue, site patrol, visitor services, waste management, and vehicle storage buildings—will provide services to the entire complex. The central laboratory facilities with their associated office and shop buildings, and assembly and staging areas, will be arranged like a small college campus.

Roads and utilities, adjacent to the campus, will include a main electrical substation consisting of incoming high-voltage electrical service, transformers, switch gear, and distribution systems. A second substation will be located on the far side of the ring. Water treatment facilities will process the cooling water used for the SSC. A road network will be needed in the campus, injector, and experimental areas, to connect the cluster regions, and to provide access to the service areas and access points located around the ring.

A significant part of the project's capital cost will go toward the 9500 superconducting magnets, whose design, construction, and testing will require advanced technologies and precision engineering of the highest order. In addition to the magnets, other advanced systems for the SSC will include the radiofrequency acceleration cavities, cryogenic facilities, particle detectors, supercomputers, and laboratory equipment.

The construction of conventional facilities, by contrast, will not require significant innovation as much as a scaling-up of existing methods. Construction of the tunnel and experimental halls, as well as the requisite infrastructure of utilities, transportation, housing, laboratories, offices, shops, maintenance, and so on, will be large in scope but straightforward in principle. It will be possible to excavate the 10-foot-diameter tunnel by cut-and-fill methods or tunnel-boring machines, or by a combination of both. The area enclosed by the ring will be left, for the most part, completely untouched.

INTENTIONAL
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13

THE SSC AS A HUMAN ENDEAVOR

An essential fact to keep in mind is that the initiation of an SSC is not simply "starting up a new large facility" but the creation of a new international basic research laboratory. This means that the efficient and prompt start-up of the new facility is only the first of several major tasks that will need to be undertaken. The second major effort is the creation of an infrastructure and environment to facilitate creative research through supporting the efforts of both inside and outside users. A third major task is the training of operating personnel to run and maintain the accelerator itself and the large ancillary complex required in support of experimental undertakings. A fourth item is the establishment of the administrative machinery to manage the SSC complex as well as to deal with the external constituencies: government, industry, the public, and the domestic and foreign participants in the work of the SSC.

The SSC will be a very large laboratory; its staff—scientists, engineers, technicians, skilled technical and mechanical laborers, and professional administrators—will number nearly 3000, including 500 visiting scientists (many on sabbatical leave from universities in the United States or abroad) and their students, who may participate in its work for periods of weeks to years throughout its operating period. Experience indicates that for each individual employed or working at a laboratory, several additional people (including families) are brought into the community in connection with schools, stores, maintenance, services, and other support facilities. Thus the SSC is likely to create additional employment in the community at large and could generate demand for additional housing, schools, and other services beyond what is required for the SSC staff itself.

3

Evaluating the Proposals

The 43 proposals originally received by the Department of Energy (of which 35 were eventually evaluated by the committee) were written in response to an April 1987 DOE document entitled *Invitation for Site Proposals for the Superconducting Super Collider (SSC)* (DOE/ER-0315). That document—the ISP—outlined the information that would be required in proposals and described the qualification criteria, technical evaluation criteria, and cost considerations that were to be used in the site selection process. (A list of the 43 proposals submitted to DOE appears in Appendix C.)

Proposals were required to show, first, that the site met a set of five qualification criteria before they could be forwarded to the committee by DOE. The qualification criteria, as stated by DOE (Section 3.2 of the ISP, p. 28), were:

> 1. Location entirely in the United States of America.
> 2. Land size and configuration to accommodate the SSC facility as specified in this Invitation. . . .
> 3. Absence of cost to the Government for land acquisition.
> 4. Capability of providing at least 250 MW of electrical power with at least 500 gpm of industrial water or 200 MW of power with 2,200 gpm of industrial water, or an appropriate interpolated combination.
> 5. Absence of known unacceptable environmental impacts from siting, constructing, operating, and decommissioning the SSC. Reasonable mitigation measures may be taken into consideration.

(Thirty-six proposals were deemed by DOE to have met the qualification criteria and were sent to the committee for evaluation. One of these was subsequently withdrawn from consideration by the State of New York.)

The ISP indicated that information in the proposals would be evaluated against a set of technical evaluation criteria and subcriteria in determining the best qualified list (BQL) and, eventually, in identifying the preferred site. As stated by DOE (Section 3.3 of the ISP, pages 28 to 29), the technical evaluation criteria were:

1. Geology and Tunneling
    A. Suitability of the topography, geology, and associated geohydrology for efficient and timely construction of the proposed SSC underground structures.
    B. Stability of the proposed geology against settlement and seismicity and other features that could adversely affect SSC operations.
    C. Installation and operational efficiency resulting from minimal depths for the accelerator complex and experimental halls.
    D. Risk of encountering major problems during construction.
2. Regional Resources
    A. Proximity of communities within commuting distance of the proposed SSC facilities capable of supporting the SSC staff, their families, and visitors. Adequacy of community resources—e.g., housing, medical services, employment opportunities for family members, recreation, and cultural resources—all available on a non-discriminatory basis.
    B. Accessibility to the site, e.g., major airport(s), railroads, and highway system serving the vicinity and site.
    C. Availability of a regional industrial base and skilled labor pool to support construction and operation of the facility.
    D. Extent and type of state, regional, and local administrative and institutional support that will be provided, e.g., assistance in obtaining permits and unifying codes and standards.
3. Environment
    A. Significance of environmental impacts from siting, constructing, operating, and decommissioning the SSC.
    B. Projected ability to comply with all applicable, relevant, and appropriate federal, state, and local environmental/safety requirements within reasonable bounds of time, cost, and litigation risk.
    C. Ability of the proposer, the DOE, or both to reasonably mitigate adverse environmental impacts to minimal levels.
4. Setting
    A. Ability of the proposer to deliver defendable title, in accordance with the schedule in [the ISP]. . . for land and estates in land that will adequately protect the Government's interest and the integrity of the SSC during construction and operation.

B. Flexibility to adjust the position of the SSC in the nearby vicinity of the proposed location.
C. Presence of natural and man-made features of the region that could adversely affect the siting, construction, and operation of the SSC.

5. Regional Conditions
A. Presence of man-made disturbances, such as vibration and noise, that could adversely impact the operation of the SSC.
B. Presence of climatic conditions that could adversely impact construction and operation of the SSC.

6. Utilities
A. Reliability and stability of the electric power generating and transmission grid systems. Flexibility for future expansion.
B. Reliability, quality, and quantity of water to meet the needs of the facility.
C. Availability of fuel, waste disposal, and sewage disposal.

In laying out the technical evaluation criteria, DOE noted in the ISP:

> In descending order of relative importance, the criteria are Geology and Tunneling, Regional Resources, Environment, Setting, Regional Conditions, and Utilities. Under each major criterion heading, the subcriteria are listed in descending order of relative importance. However, a serious deficiency in any one subcriterion may prevent the proposal from being included in the BQL.

DOE further stated that "cost considerations are important to the selection process and will be used in conjunction with the technical evaluation criteria in selecting the most desirable site." The department indicated that it would prepare a life cycle cost (LCC) estimate for each proposal and stated:

> Although cost considerations are significant, primary emphasis will be placed on the results from the evaluation of the technical evaluation criteria by the NAS/NAE in the development of their BQL recommendation to the DOE.

The process used by the committee was consistent with the instructions provided in the ISP. Early in its life, before any proposals had been received by DOE, the committee agreed on a set of procedures designed to permit the detailed and equitable evaluation of the voluminous set of proposals and supporting materials that it expected to receive and ultimately did.

The committee was faced with the task of evaluating the proposals using a multiplicity of technical criteria and subcriteria and costs. Because of the difficulty—perhaps impossibility—of directly comparing the various criteria and the extent to which individual proposals met or did not meet the criteria, the committee decided against adopting a rigid set of weights that would allow a mechanical means of scoring or grading proposals.

Seven working groups, focusing on each of the six criteria and costs, were established by the committee to assure careful, detailed examination of each proposal. Each working group was composed of members of the committee with particular expertise in its area of focus. The working groups were charged with identifying strengths and weaknesses of the proposals in their areas of concern and with providing an initial evaluation of proposals on a scale with three values (good, satisfactory, and questionable) as a basis for discussion by the full committee. The committee did not seek to verify independently and systematically information presented in the proposals; such verification may be necessary in subsequent stages of the site selection process. In its review of proposed plans for timely acquisition of the required land, the committee received assistance from the U.S. Army Corps of Engineers drawing upon that agency's long experience and substantial expertise for an analysis of the plans.

From the outset, the committee recognized the complexity of aggregating ratings for all the criteria and subcriteria. It noted that any single mechanical method (such as assignment of explicit numerical weights, explicit cutoff ranges for individual criteria or subcriteria, or preselected stepwise disqualification rules) would embody potential technical and practical flaws that would make its adoption by the committee unwarranted. Thus, although the committee asked its staff to try alternative aggregation methods and to note their sensitivity to basic assumptions, the committee used the ratings of individual members and working groups, and the staff analyses of sensitivity to different assumptions, only as guides to direct its discussions and deliberations.

At its final meeting, the committee discussed the strengths and weaknesses of the 35 proposals that remained for evaluation and for each site made an explicit determination of whether or not the site merited inclusion on the best qualified list. No explicit weighting or ranking was used to determine the list; thus the list itself is an unranked list of the best-qualified sites. At no point did the committee consider an "appropriate" length for the list. The best qualified list presented in this report is the result of 35 decisions made by the committee after careful consideration of the proposals, and the list includes all the sites on which a committee consensus for inclusion was reached. The list represents the best collective judgment of 21 individuals, carefully chosen for their expertise and impartiality, after a detailed assessment of the proposals using 19 technical subcriteria and DOE's life cycle cost estimates.

The committee recognized that it was dealing with proposals prepared by proponents of sites and that it was therefore likely that proposals would present sites in the best possible light. One way of obtaining additional information about some or all of the proposed sites might have been through visits to the sites. However, because the procedures for site selection presented in the ISP precluded site visits by the committee, and because the time constraints under which the committee was asked to work would have made any but the most superficial site visits difficult or impossible, the committee did not visit any sites as part of its evaluation. The committee is confident that the breadth of experience represented by its members and its detailed and comprehensive discussion of individual proposals were sufficient to assure that each proposal received adequate and equitable consideration and that the best qualified list reflects a judicious selection of those sites that best meet the selection criteria listed in the ISP. The committee does believe that site visits can provide a valuable means of confirming the information contained in the proposals and urges that, in further action by the Department of Energy on selection of a preferred location for the SSC, site visits and other confirmatory studies be used.

In the next chapter of this report, the committee presents an outline of some of the factors that weighed most heavily in its deliberations. This is followed by a chapter that briefly comments on the strengths and weaknesses of the sites that, in the judgment of the committee, were the best qualified of the proposed locations for the SSC.

4

Comments on the Evaluation of Site Proposals

The discussion of criteria for the evaluation of site proposals in the *Invitation for Site Proposals* is quite detailed and complete. Nonetheless, in its discussions and deliberations, the committee had occasion to elaborate and interpret several of the criteria in order to evaluate the adequacy of a given site proposal in terms of particular criteria and subcriteria.

The committee was asked by DOE to perform an evaluation of the site proposals ". . . developed in the light of past experience with large science research laboratories," and to "stress those items within the DOE-announced criteria and subcriteria and their relative importance, that are likely to be most critical in determining scientific productivity of the SSC laboratory. . . ."

GEOLOGY AND TUNNELING

Among the geological conditions for SSC construction that the committee considered to be favorable were groundwater table below the tunnel and experimental hall levels; rock or soil with low permeability; uniform rock and soil conditions for the entire tunnel or for long sections; rock or soil soft enough to allow for rapid excavation or tunnel advance rate; rock or soil strong enough to stand without support in the tunnel or in steep, high, open cuts; topography allowing efficient open-cut excavation or placement of the tunnel at relatively shallow depths; and geological conditions permitting minimal tunnel lining and support or no lining and support at all.

Among the unfavorable conditions for construction were: groundwater table at or near surface; high-permeability rock or soil; high hydraulic head because of an overall deep tunnel or mountainous topography; presence of surface water (swamps, lakes, rivers, or streams) that would complicate access or construction or provide recharge for inflows into the tunnel or open excavations; complex rock and soil types with many changes and wide variations in properties; low-strength rock and soil materials (such as loose sands or soft clays) that would require immediate support; hard or abrasive rock; particularly deep tunnels with shafts over a few hundred feet deep caused by topographical features; need for complicated, time-consuming, or highly specialized tunneling procedures to accommodate particular conditions; conditions necessitating slow tunnel advance or open-cut excavation rates; swelling or slaking soil or rock; and highly fractured rock that would require support.

The impact of geology on operational stability was also considered. Here, favorable sites were generally characterized by low soil or shale consolidation or heave; absence of active faults or zones of volcanic activity; low seismic exposure; absence of conditions for potential liquefaction or soil deformation; and formations not subject to adverse subsidence from subsurface fluid withdrawal, solution cavities, or mines.

Adverse site features for operational stability included the opposite of each of the favorable conditions listed above and, in addition, potential groundwater inflow leaking through construction joints; possibility of long-term sulfide attack on concrete and corrosion resulting from leakage into the tunnel; and potential toxic gas leakage into the tunnel.

The primary factors examined in considering the efficiency of installation and operation of the accelerator complex and experimental halls were depth, ease of excavation, and support requirements. In general, a site was found more suitable if it was characterized by shallow depth of cover at the experimental halls and conditions that would allow simple excavation and support procedures.

Construction risk, another of the geology subcriteria, was also examined. Here sites were judged positively if the geology was relatively simple or well understood and if the proposed method of excavation was shown to be compatible with the possible ground and water conditions that could be encountered. Sites were found to be risky or uncertain if they showed lack of geological information or unknown conditions; fault zones, shear zones, or hydrothermal alteration; mixed-face conditions; flowing ground (e.g., water-saturated sands); complex or highly variable geology making it difficult to predict conditions and requiring possible sudden changes in tunneling or excavation methods or water handling; existence of possible large volumes or sudden inflows of groundwater; cavities from rock solution or lava tubes; gas (methane or hydrogen sulfide) with potential for explosion or toxic effects requiring special lining of tunnel and enhanced ventilation systems; buried valleys; and stresses that could cause rock burst or squeezing ground.

REGIONAL RESOURCES

The various components of what are called in the ISP "regional resources" are less amenable to detailed technical analysis than are geological conditions. The committee was faced with the question of identifying which regional resources are most important to the efficient and effective construction, start-up, and operation of a major scientific facility and laboratory. The criteria and subcriteria listed by DOE in the ISP are, in general, comprehensive, but they provide little guidance as to which components will be most important to the eventual success of the SSC. In its deliberations, the committee found a number of components of regional resources to be of particular importance.

Because the SSC will be a very large national laboratory, its ability to attract and retain a first-class staff is of utmost importance to its scientific success. Scientists, engineers, skilled technicians, mechanical laborers, and professional administrators will number about 3000, including several hundred visiting scientists—many on sabbatical leave from U.S. or foreign universities—who may be in residence for periods of weeks to years. Although it may be the case that some high-energy physicists will be drawn to the SSC wherever it is located, this is not the case for most of those who will be involved in the enterprise. What is likely to attract a staff? Community proximity is one factor; other factors include housing, educational, and employment opportunities for staff, visitors, and their families. In this regard, the committee noted the very real and growing importance of employment opportunities for spouses of permanent and visiting staff members. A variety of cultural and recreational options, as well as an openness to various lifestyles, is highly desirable if the laboratory and the surrounding communities are to provide an hospitable environment for the diverse (and international) group of people who will be in residence. The quality of medical facilities and local schools is likely to be of great concern to the staff and visiting scientists. It should be noted that while it is not essential for cultural and educational resources (such as universities, museums, and theaters) or recreational opportunities to be immediately adjacent to the laboratory, they should be reasonably accessible. As might be expected, there was no detailed consensus among committee members about how close "close enough" is, though there was agreement on the general proposition that the closer the amenities the better.

Ease of access to the laboratory itself received considerable attention. Reasonable proximity to a well-serviced airport was seen to be quite crucial, although here again, no detailed definitions of "reasonable proximity" or "well-serviced" were developed. Access to the site by highway and railroad networks was also treated as an important factor.

Construction, start-up, and operation of the SSC will require the availability of an adequate local or regional labor pool of skilled engineers, technicians, administrators, and construction workers, the existence of heavy construction capability, and the availability of machine and electronics shops experienced in high-technology applications and vendors with sizeable stocks of small items (pumps, motors, tools, and the like).

The final subcriterion in this area, relating to local and regional cooperation, created considerable difficulty for the committee's deliberations on certain proposals. The material germane to this issue provided in individual proposals varied greatly in quality and completeness, although in almost all cases the proposals indicated that there would be active and effective administrative and institutional support. The result was that the committee was unable to use this subcriterion to discriminate effectively among the proposals. During the course of the committee's work, there have been numerous newspaper accounts of local opposition and support at a number of sites. In addition, members of the committee and staff received numerous letters, signed petitions, and other supplementary materials from individuals and organized groups, most of them attacking particular proposals. Because the committee was charged with reviewing the proposals themselves, because it had no reliable way to gauge the validity or representativeness of the letters or press reports, and because it was unable to evaluate the information received in these letters and reports, the committee agreed not to use this information in its deliberations. The committee strongly believes, however, that community acceptability, support, and cooperation will be important factors that must be considered carefully by DOE as it examines the best-qualified sites in the next stage of the site selection process.

ENVIRONMENT

Environmental impacts of construction and operation of the SSC were carefully considered. For purposes of analysis, each proposal was examined to determine effects on earth resources, water resources, air resources, ecological resources, health and safety, land use, socioeconomics, scenic and visual resources, and cultural and historical resources. Compliance with federal, state, and local laws and regulations and possible mitigative measures also received attention.

In its review, the committee found that no site proposal presented environmental problems that could not be prevented or minimized. However, some site proposals suggested environmental strengths or weaknesses that distinguished them from other proposals. A partial list of weaknesses found in some proposals will suffice to describe the kinds of environmental factors that were considered to be of importance by committee members (for the most part, environmental strengths were taken to be the converse of the weakness): critical environments and habitats likely to be disturbed or placed at risk; federally or state designated endangered, threatened, or special interest species significantly disturbed; managed fish or wildlife resources likely to be affected; impacts on surface water resources; impacts on groundwater resources; loss of prime agricultural land; impacts on federal or state recreational, wildlife refuge, fish and game management area, or wilderness area; impacts on historical or archaeological resources; impacts on local topography, stream courses, or scenic resources; impediments to access to gas, oil, coal, or mineral resources; impacts on air quality that could affect ability to attain air quality standards; noise or vibration likely to disturb sensitive human activity or animal populations; possible risks to health or safety from construction or operation of the SSC; and inadequate information about proposed mitigation actions.

OTHER TECHNICAL CRITERIA

The committee considered the other criteria listed in the *Invitation for Site Proposals*: setting (and principally the strengths and deficiencies of the various plans for timely acquisition of the required land), regional conditions, and utilities.

Among the regional conditions examined by the committee, noise, vibration, climate, weather conditions, and site-specific land use and activities that might affect construction and operation of the SSC received particular attention. There were some significant differences among the sites—such as major railroads crossing the proposed collider ring in a few cases, the presence of quarries and other noise and vibration sources at some sites, and severe climate conditions that might affect construction or operation in some locations—no site was characterized by such negative regional conditions that it could be eliminated on this basis alone. Thus, for example, at those few sites that had potential noise and vibration problems, it was felt that effective remedial actions were possible.

The last of the technical evaluation criteria—utilities—provided little discrimination among the sites; all but one of the proposals demonstrated the ability to provide reliable and stable electric power, water, and fuel, and to handle the wastes generated in the construction and operation of the SSC.

COST

As noted earlier, costs were to be considered in the evaluation of site proposals, although the precise mechanism for their inclusion in the evaluation was not specified in the *Invitation for Site Proposals.*

Working with a contractor, DOE devoted extensive effort to the calculation of the absolute and relative costs of construction and operation of the SSC at each of the various sites proposed. DOE provided the results of the calculations to the committee during the course of its deliberations. The basic calculations were carried out using procedures that committee members felt were reasonably consistent with currently accepted economic practice. The calculations themselves were painstaking and extensive, but they were unavoidably based, in part, on estimates of future outlays about which there was considerable uncertainty. Social benefits and costs, such as contributions to local employment and environmental damage problems, were considered separately and, because of a paucity of definitive data, more or less informally.

Cost calculations did play a role in the final evaluation process, but that role was more minor than might have been anticipated. The reason was not lack of concern by members of the committee over the costs. The reason was, rather, the remarkably narrow range within which cost estimates for the different sites fell. The cost of the most expensive sites was only a few percent above the average for the group, and that of the most economical site was only a few percent below the average. Since the range of uncertainty was no doubt at least comparable in magnitude, this obviously weakened considerably the committee's ability to distinguish among the site proposals in terms of the costs each could be expected to entail.

The narrowness of the range of calculated cost results in part from imperfect ability to foresee future costs, particularly as they would be affected by unforeseeable contingencies. But the uncertainty is clearly an unavoidable attribute of the nature of the task.

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The Best Qualified List

In agreeing on a best qualified list, the committee took as its goal precisely that articulated by DOE in the ***Invitation for Site Proposals***: ". . . to select [sites] that will permit the highest level of research productivity and overall effectiveness of the SSC facility at a reasonable cost of construction and operation and with minimal adverse impact on the environment." The committee is confident that the list that follows meets that goal in the sense that a productive and effective SSC could be built and operated at any of the sites on the list.

In alphabetical order, the sites on the best qualified list are:

ARIZONA/MARICOPA

The Maricopa site is located about 35 miles southwest of Phoenix in an area of desert plains bisected by a mountain range.

The SSC would be located in an area whose geology is quite favorable for construction using a combination of cut-and-fill and tunneling methods. Much of the planned ring would be in fanglomerate (a lightly cemented sedimentary rock resulting from coalescing alluvial fans), which allows rapid advance rates by either method. The remainder of the tunnel would pass through a mixture of fanglomerate, granitic rocks, and interbedded volcanic and sedimentary rocks; here, too, tunneling is easily accomplished. Water problems are unlikely since the ring would pass through unsaturated materials and lie above the water table.

Although the geology is generally quite good, there are a few comparative weaknesses of the site in this regard, most notably the need for considerable mixed-face tunneling, the interception of possible faults and shear zones (particularly in the granitic segments), and the uncertainty arising from the limited availability of information on the moderately complex mountainous terrain. Some deep shafts would be required in parts of the ring that would pass through the mountainous area.

The regional resources necessary for the construction and operation of the SSC are present at or near the site. The area has a strong technical and labor base whose effects can already be seen in the growing electronic and semiconductor industry and scientific laboratories in the region. Convenient access and housing, and employment and educational opportunities are all available, although some upgrading of roads and highways in the immediate vicinity of the proposed site would be needed.

The SSC would be unlikely to cause major environmental impacts at the site; indeed, the proposal demonstrates the possibility that the project could actually enhance a somewhat degraded environment by salvaging and replanting desert vegetation. The Arizona proposal was particularly strong in its response to the environmental criterion of the ISP.

A relatively small number of property owners would be affected by the land acquisition plan. Much of the land required for the site is federal land under the administration of the Bureau of Land Management of the Department of Interior.

A main and busy branch of the Southern Pacific Railroad would cross directly over the SSC ring; the proposal states that vibration problems from the railroad, if they exist, could be mitigated. Otherwise, no serious deleterious regional conditions were noted by the committee.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Maricopa site would be slightly higher than the mean costs for all proposed sites, although the difference from the mean is smaller than the likely accuracy of the estimates themselves.

COLORADO

The Colorado site is in an area of slightly hilly topography in a region of grasslands some 60 to 70 miles northeast of Denver.

The SSC would be located in an area whose geology is very simple and predictable (100 percent Pierre shale) and would enable rapid construction—advance rates consistent with estimates in the proposal—using routine tunnel boring machines. The shafts and other experimental facilities would be surface excavated, and they are moderately shallow, the average depth to the ring being about 100 feet. Groundwater problems would be minimal in this impermeable rock.

Although the geology is highly favorable, there are a few comparative weaknesses involving construction. The shale would need immediate sealing to prevent slaking—i.e., the breaking up of shale upon exposure to air—and some routine dewatering would be required for shafts and interaction chambers in the near-surface soils. Deep foundations would be required for surface structures, but this is a routine construction method in the area.

The proposed site would draw on the strong regional resources of the somewhat distant Denver and Boulder areas, although the distance would make easy commuting or ready access to the employment, housing, and cultural resources difficult. A comparative weakness is the current virtual absence of communities in close proximity to the proposed facility. The location of the newly planned airport and the outward growth of Denver are likely to help this situation. The transportation systems are good, and Colorado proposes to improve access by constructing a new highway to the site.

Major environmental impacts from construction are unlikely, as the tunnel would be bored with modest habitat disturbance. For the surface excavations and structures, any impacts resulting from the construction could be readily minimized.

Relatively few property owners would be affected by the land acquisition plan, and few relocations would be necessary; the appropriate legislation is in place. Although regional conditions at the site are good in general, some attention must be paid to possible vibration due to nearby oil well pumping.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Colorado site would be slightly less than the mean costs for all proposed sites, although the difference from the mean is smaller than the likely accuracy of the estimates themselves.

ILLINOIS

The Illinois site is located about 40 miles west of Chicago, directly west of the Fermi National Accelerator Laboratory in Batavia.

The SSC would be located in a flat to gently rolling area, and the tunnel would be excavated in uniform dolomite. There is extensive tunneling experience in the area, and the rock can easily be excavated by machine with excellent advance rates and minimal required support. The experimental halls would be mined excavations with minimal roof supports of rock bolts and reinforced shotcrete.

A weakness of this site would be the depth of excavation (generally between 270 and 430 feet) and routine groundwater control required for shafts.

The Chicago area is a major urban center offering a wide array of excellent regional resources, including universities and diverse cultural and recreational activities. An extensive transportation infrastructure, including highway, air, rail, and water, is in place. Also in plentiful supply are machine tool and fabrication companies, as well as a skilled labor force experienced in high-technology applications. Ample housing is available in the numerous neighboring communities.

An additional strength of the site is an existing infrastructure built upon on almost two decades of experience in operating an outstanding high-energy physics research laboratory.

Tunneling would be done by boring machine, thus reducing effects on the surface. The site has no developed oil, gas, or coal deposits; impacts on surface and ground waters would probably be modest; no highly sensitive animal or human population is likely to be affected by SSC operational noise; and no federally endangered or threatened species or Illinois species of interest is at risk.

Weaknesses include air quality attainment problems in the Chicago area with respect to ozone; loss of some prime farmland and wetland habitat; and a risk of increased siltation of streams during construction. These negative impacts can probably be satisfactorily minimized by such steps as lease back and creation of new wetlands.

A rather large, complex acquisition and relocation program would be involved in conveying the land, but the state has already enacted the Superconducting Super Collider Act of Illinois, granting quick-take land acquisition authority.

The presence of quarries and gravel pits at the site requires some study but does not appear to present a fundamental difficulty. Climate conditions are not as favorable as at some other sites.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Illinois site would be slightly higher than the mean costs for all proposed sites; if credit is allowed for the use of components of the existing Tevatron, however, the site becomes one of the less costly.*

MICHIGAN/STOCKBRIDGE

The Stockbridge site is located in a relatively flat, predominantly rural farming and recreational area in the south central portion of Michigan, approximately 35 miles from Ann Arbor and equidistant from East Lansing.

The geology of the proposed site is on the whole favorable for construction of a tunnel driven through shales, limestone, dolomites, and sandstone. A tunnel through such formations is likely to include long unlined sections and relatively high advance rates. There are, however, a few comparative weaknesses, including the need for significant groundwater control in certain tunnel sections. Groundwater is found near the surface, and dewatering of shafts as well as slurry walls for experimental halls would be necessary. In addition, there is a risk of encountering a buried valley during tunneling.

Regional resources essential for construction and operation of the SSC are present at or near the site. The area is close to two major research universities, and it offers diversified housing, recreational

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*In the course of its evaluation of the Illinois proposal, the committee was given the report of a DOE-sponsored study on the technical feasibility and estimated costs that would be involved in using the Fermilab Tevatron complex as an injector for the SSC. (*Analysis of the Fermilab Tevatron as an Injector for the SSC*, RTK, October 1987.) The report concludes that, with certain modifications and improvements, it is reasonable to expect that the existing Fermilab accelerators could meet SSC design requirements. Cost estimates for the alterations are given, although they show a wide range because of uncertainty about whether or not the existing main ring would have to be replaced to meet SSC performance specifications. (Further measurements at Fermilab would be necessary to determine the need for replacement of the main ring.) Although the committee did not question the report's conclusions, it did note that the report does not discuss whether the Tevatron would meet reliability criteria for the SSC. Given the importance of the reliability of the injector to the SSC and the age of the Tevatron magnets and components, some members of the committee felt that some or all of the aging components might have to be replaced. If this were necessary, there would, of course, be cost implications that are not discussed in the report.

and employment opportunities, and reasonable access to the Detroit International Airport. It has an excellent industrial base including large numbers of machine shops and a major concentration of advanced technology manufacturers.

An SSC would be likely to cause relatively limited environmental effects at the site. There are no threatened or endangered species or habitats at risk in the area, and there would be little likelihood of significant impacts on scenic aspects of the area because tunneling detritus would be disposed of in nearby gravel pits. An SSC is unlikely to add significantly to environmental air pollution in this nonattainment area for ozone, but several historical and archaeological sites may require attention. Some abundant stream courses will need protection during construction in order to preserve wetland habitats.

Michigan has proposed a complex, time-sensitive plan for acquisition of the site. There are some 700 landowners whose parcels must be purchased and 221 homes and residences whose occupants must be relocated under reasonable state acquisition laws and procedures.

The proposal states that a number of roads and railroads would cross directly over the SSC ring; it is expected that vibration problems either would not be severe or could be minimized. Winters in the area are somewhat cold and snowy.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Stockbridge site would be very close to the average for all proposed sites.

NEW YORK/ROCHESTER

New York proposes a site for the SSC in a moderately hilly location between the cities of Rochester and Syracuse on the shore of Lake Ontario in the central portion of the state. The site is currently about two-fifths in forest and brush and three-fifths in agriculture. The major SSC facilities would be located about 18 miles east of Rochester.

The site's geology, which is favorable for construction of a tunnel at medium depth, is marked by surficial glacial drumlins (oval hills caused by glacial drift) underlain by interbedded sedimentary rocks. Its specific strengths include good tunneling conditions in sedimentary rocks with well-understood and predictable geology leading to rapid advance rates and minimal required support. Cut-and-fill construction techniques could be used for the near cluster experimental halls and underground excavations for the far cluster. Comparative site weaknesses are the presence of hydrogen sulfide and methane gas requiring continual ventilation or other controls, corrosive sulfate water requiring special concrete tunnel lining, local artesian groundwater conditions, and high in-situ stresses that might cause localized spalling in the shaly materials.

Regional resources necessary for construction and operation of the SSC are present at or near the site. The area allows access to several colleges and research universities, with a good range of living, educational, employment, and recreational opportunities. A particular strength of the area is its advanced technology industrial production and research base. The site is less readily accessible than several others.

Construction and operation of the SSC are likely to have relatively limited environmental effects in the region. No rare habitats are threatened, and no long-term impacts would be expected on surface and ground waters. In addition, the area's air quality attainment is likely to remain within federal standards, and tunneling and construction spoils could be disposed of in local quarries. Construction would be expected to remove prime farmland from production, although the amount could be reduced by lease back, and the loss of some wetlands would require examination. Several historical and archaeological sites might need special consideration.

A number of roads and railroads would cross directly over the SSC ring; the proposal anticipates that vibration problems at the interaction points either would not be severe or could be mitigated. Winters in the area are cold and very snowy, and they could affect a construction schedule for surface facilities.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Rochester site would be slightly lower than the mean costs for all proposed sites, although the difference from the mean is smaller than the likely accuracy of the estimates themselves.

The Rochester site was one of those about which committee members and staff received a large number of letters and supplementary materials from residents of the area. Almost all the letters opposed the site. As noted earlier, the committee was unable to use the letters in its evaluation of the site; but it feels strongly that DOE must, in the next stage of the site selection process, look closely at the extent to which the vocal opposition represents a true absence of local support.

NORTH CAROLINA

North Carolina proposes a site near its northern border with Virginia. Located in rolling terrain in a rural, mostly forested area near the cities of Durham and Raleigh, the site's campus would be about 20 miles from Research Triangle Park.

The tunnel would be bored in interlayered metamorphosed volcanic and sedimentary rocks. The average depth below the surface would be about 175 feet, and the site's experimental halls would be in excavated caverns. The geological advantages of the site include favorable tunneling characteristics that promise rapid excavation and little need for supports. Site weaknesses include a major shear zone, localized areas of potential instabilities, and probable modest water inflow in some areas.

The North Carolina site is generally quite strong in local attributes that would attract and support the scientific and technical staff of the SSC. The immediate proximity of several major research universities, the presence of urban amenities including those of Research Triangle Park, and employment prospects for family members of staff are notable. Accessibility to transportation is adequate but less strong than for some other sites, although Raleigh-Durham Airport serves as a hub for a major air carrier and is currently undergoing significant expansion.

The site is generally favorable on environmental grounds, with no major risk to identified species or critical habitats and very little long-term impact on wetlands or water quality, but the discussion of this last matter in the proposal was not very extensive. The environmental disadvantages that exist are generally associated with effects of urbanization on an area that is now largely forested. However, some prime farmland would be lost, and about 100 relocations would be required, including several facilities of the North Carolina National Guard.

Regional conditions for this site are quite good, with only seasonal rains creating slight problems for year-round construction.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the

North Carolina site would be slightly below the average for all proposed sites, although the difference from the mean is smaller than the likely accuracy of the cost estimates.

TENNESSEE

Tennessee proposes a site in the central part of the state, near the city of Murfreesboro and about 30 miles southeast of Nashville. The area is one of generally rolling to hilly terrain, and the site mainly occupies undeveloped rural lands.

Geological conditions are generally favorable. The collider tunnel would be bored through a bed of homogeneous Ordovician limestone at an average depth of about 400 feet below the surface. The tunnel would be placed below the zone in which groundwater would present an impediment. Strengths of the site include favorable prospects for rapid machine excavation with minimal support and lining. The experimental halls would be mined excavations requiring minimal roof supports. Comparative drawbacks include the tunnel depth and karst solution features in the upper 200 feet, which would require groundwater control during shaft construction.

The site is near the requisite regional resources, as is reflected in recent decisions by General Motors and Nissan Motor Company to locate new plants in the area. The site is easily accessible through the Nashville Metropolitan Airport, which serves as a hub for a major air carrier and is currently undergoing significant expansion. There are other important local resources, including the nearby city of Nashville and Vanderbilt University.

The depth of the facility would minimize environmental impacts. There would be neither significant loss of prime farmland, nor significant risk to wetlands, surface waters, or groundwater, and the placement of the project's surface features is such that it would avoid impacts on the cedar glade and limestone cave habitats present in the area. However, the presence of several threatened and endangered species and the presence of historic structures would require special attention.

Regional conditions at the site are good, with the only drawback of note being seasonal rains that could slightly affect the construction schedule.

According to the DOE estimates, the Tennessee site ranks among the lowest in construction costs and labor rates. Its overall life cycle costs are estimated at slightly below the mean for all sites.

TEXAS/DALLAS-FORT WORTH

The Dallas-Fort Worth site is in an area of gently rolling prairie about 30 miles south of Dallas.

The SSC would be located in an area whose geology is excellent for construction. The planned ring would be in chalk and marl, which allow for very high advance rates using tunnel boring machines (based on tunneling experience elsewhere in the same formations) and are at the same time of high strength, permitting a minimum of support and lining. The shafts and other experimental facilities would be surface-excavated and of moderate depth. A few of the experimental halls would range from 165 to 220 feet below the surface; the strength of the rocks would permit stable, unsupported, near-vertical cuts.

Although the geology is quite favorable for SSC construction, there are a few comparative weaknesses. Several of the experimental halls that bottom in shale have a potential bottom heave; there are plans to relocate these halls to avoid the shale. Within the marl there are local slickensided blocky ground and slaking (breaking up of the marl upon exposure to air); the marl in surface excavations would need to be sealed fairly soon after exposure. Excavations in weathered marl would need to be supported.

The regional resources and technological base of the region offer most of the advantages of a major urban center. The Dallas-Fort Worth airport is one of the nation's leading air hubs and a major international point of entry. In addition, the transportation network of highways and railroads is excellent. There is a diversity of attractive housing in the region, and cultural, recreational, educational, and employment opportunities are plentiful. The SSC is unlikely to have major environmental impacts on the site because the tunnel would be bored with modest habitat disruption. One of the comparative weaknesses is that a substantial acreage of prime farmland would be lost, but lease-back opportunities might diminish much of this.

There are a moderate number of property owners (420), and a number of residences and businesses would be affected (224) by site acquisition. Slightly less than one-half of the land would be in stratified fee. The acquisition plan is well conceived and could easily be executed.

Regional conditions at the site appear quite good, with only a few possible vibration sources requiring some attention.

According to the life cycle cost estimates provided by DOE, construction and operating costs for a super collider located at the Dallas-Fort Worth site would be slightly less than the mean costs for all proposed sites, but the difference from the mean is smaller than the likely accuracy of the estimates themselves.

SITES NOT ON THE BEST QUALIFIED LIST

As noted earlier, the committee used a procedure for examination of the proposals that it developed before receipt of any proposals from DOE. The procedure involved careful examination of each proposal by working groups that paid particular attention to criteria in their areas of expertise. The working groups reported to the full committee on the results of their examinations, including an initial evaluation of each proposal using the categories good, satisfactory, and questionable. The reports formed part of the basis for the committee's discussions and final deliberations. Those deliberations involved the review and synthesis of a vast amount of information by a group with broad and varied experience, perspectives, and expertise. The very nature of this process does not permit determination of the extent to which any specific factor or combination of factors influenced how individual judgments were formed or a group consensus achieved. Nonetheless, some general comments are possible and warranted.

Among the remaining sites, a number displayed unfavorable geological conditions. Some sites were likely to be subject to excessive water inflow during tunneling; others could be expected to demonstrate uneven subsidence from subsurface fluid withdrawal. A small number were characterized by seismicity or zones of volcanic activity that could present problems in the operation of the SSC. Finally, some sites demonstrated complex or uncertain geological characteristics that suggested possible substantial delays in construction.

Other proposed sites, including some with quite favorable geological characteristics, were less successful in meeting the regional resources criteria than were those included on the best qualified list. Several lacked existing communities near the site; others were not particularly accessible because of their distance from a major, well-serviced airport. In some cases, there was no evidence of a strong infrastructure of machine and electronics shops, vendors, or labor force experience in high-technology endeavors. A few sites were quite distant from universities and medical centers; others did not offer opportunities for professional employment of spouses of SSC staff.

No site presented insurmountable environmental problems, or unsolvable problems of site acquisition or regional conditions, although, as might be expected, some sites would have posed more serious difficulties than others.

It should be noted, again, that the committee chose not to adopt any arbitrary set of scores or weights to reach its decision about the inclusion or exclusion of any particular site on the best qualified list. The list, then, is the outcome of committee judgment about which sites most effectively demonstrated in their proposals that they met or could meet the set of criteria established by DOE at the start of the site selection process.

Appendix A: Statement of Work for the Committee

The National Academies of Sciences and Engineering (Academies) shall assist the Department of Energy (DOE) in the Superconducting Super Collider (SSC) site evaluation process by evaluating the suitability of proposed sites for the SSC facility. Time is of the essence. The Presidents of the Academies will jointly appoint a Site Evaluation Committee (Committee) reporting directly to the Academies' Governing Board of the National Research Council. The Committee shall consist of about 15 distinguished scientists, engineers, and other individuals and will be appointed giving due consideration to potential real or apparent conflicts of interest and geographical distribution.

The Academies shall:

1. Consult with DOE officials as those officials determine the evaluation criteria, subcriteria, and considerations to be announced in the DOE Invitation for Site Proposals as well as broad indications of the relative importance of those criteria, subcriteria, and considerations. (In the absence of Committee members, Academies' officials shall carry out the consultation.) The Committee shall establish (prior to receipt of proposals) techniques, processes, and special analyses to be employed in evaluating proposals using the DOE-announced criteria and subcriteria and their relative importance. The Committee's evaluation, to be developed in the light of past

experience with large science research laboratories, will stress those items within the DOE-announced criteria and subcriteria and their relative importance, that are likely to be most critical in determining scientific productivity of the SSC laboratory.

2. Restrict its attention to those sites referred to it by DOE for consideration and evaluation.

3. Perform, or cause to be performed, special analyses, as deemed appropriate, of required site characteristics.

4. Develop a process that will assure expeditious evaluations resulting in the identification of a small number of best qualified sites from among those considered, i.e., a Best Qualified List (BQL).

5. Obtain clarifications, if determined to be appropriate, from any site proposer. Proposers may not modify their proposals during, or as a result of, any such clarifications. Further, designated DOE personnel will be invited to be present during the Committee's meetings with proposers.

6. Prepare a final report to the DOE Director of Energy Research no later than three (3) months after the DOE formally provides the Academies with the proposals to be evaluated. The report shall describe the evaluation process; the rationale employed, including emphasis, in the development of the BQL; and assessments of those sites included in the BQL. The BQL shall not be prioritized.

7. Until release of the Academies' final report after the DOE announces the preferred site, maintain the confidentiality of DOE provided sensitive material which has not been made public by the Government, as well as the Academies' proceedings and results, from all but DOE officials designated by the Director of Energy Research. If DOE has given the Academies access to proprietary information (labeled as such) owned by or in the possession of DOE, the Academies will protect such information from unauthorized disclosure to the extent permitted by law so long as the information remains proprietary. (The term "proprietary information" means trade secrets and commercial or financial information obtained from a person and privileged or confidential.)

8. At their option, release their recommended list of best qualified sites, after the list is determined and provided to DOE and release is coordinated with DOE. The report of the Academies shall include a discussion of the strengths and weaknesses of the proposals included in the recommended BQL. To insure the integrity of the DOE competitive selections process and prevent the details of proposals still under consideration from being made public during the

process, the report shall not be made public until DOE announces the preferred site.

9. Be prepared to respond to DOE regarding substantive questions about its recommendations; after release of the Academies' report to the public, the Committee shall be prepared and respond to substantive questions from others.

10. Interact closely with DOE without compromising the real or perceived independence of the Academies' evaluation effort. The Academies will routinely inform DOE in advance of all Committee meetings. DOE designated personnel will be invited to all Committee meetings, except Executive Sessions deemed necessary by the Academies. DOE shall provide information and analyses to the Committee when necessary.

Appendix B
Meetings of the Committee and Its Subgroups

June 30-July 1	Committee	National Academy of Sciences, Washington, D.C.
July 15	Regional Resources Subgroup	Telephone Conference
July 28	Costs Subgroup	New York University; 269 Mercer Street, N.Y., N.Y.
August 31	Regional Resources Subgroup	National Academy of Sciences, Washington, D.C.
September 21-22	Geology and Tunneling Subgroup	Sheraton Airport Hotel, Denver, Colorado
October 5-7	Geology and Tunneling Subgroup	Pacific Gas and Electric, San Francisco, California

October 6	Utilities Subgroup	Southern California Edison Rosemead, California
October 8	Environment Subgroup	Scripps Institution of Oceanography, La Jolla, California
October 8	Regional Resources Subgroup	Scripps Institution of Oceanography, La Jolla, California
October 8	Settings Subgroup	Scripps Institution of Oceanography, La Jolla, California
October 8-10	Committee	Scripps Institution of Oceanography, La Jolla, California
October 9	Regional Conditions Subgroup	Scripps Institution of Oceanography, La Jolla, California
November 13-14	Committee	National Academy of Sciences, Washington, D.C.

Appendix C
September 17 Letter from James F. Decker to Edward A. Frieman

Department of Energy
Washington, DC 20585

September 17, 1987

SEP 18 1987

Dr. Edward Frieman
Chairman
Super Collider Site Evaluation Committee
National Academy of Sciences/National Academy of Engineering
2101 Constitution Avenue, NW
Washington, DC 20418

Dear Dr. Frieman:

The Department of Energy (DOE) has completed its review of the Superconducting Super Collider (SSC) site proposals against the qualification criteria included in the Invitation for Site Proposals for the SSC (Invitation). The Invitation required that proposals either not meeting the qualification criteria or which are so grossly or obviously deficient as to be totally unacceptable will not be evaluated.

Proposers were asked to demonstrate, certify, or both that the following criteria are met in the proposal:

1. Location entirely in the United States of America.
2. Land size and configuration to accommodate the SSC facility as specified in this Invitation, including Figure 1-2 and Table B-1.
3. Absence of cost to the Government for land acquisition.
4. Capability of providing at least 250 MW of electrical power with at least 500 gpm of industrial water or 200 MW of power with 2,200 gpm of industrial water, or an appropriate interpolated combination.
5. Absence of known unacceptable environmental impacts from siting, constructing, operating, and decommissioning the SSC. Reasonable mitigation measures may be taken into consideration.

Forty-three (43) proposals were submitted by the 2:00 p.m. deadline September 2, 1987. The DOE has determined that the thirty-six (36) proposals identified in Attachment 1 are qualified and are referred to the National Academy of Sciences/National Academy of Engineering (NAS/NAE) for evaluation. Seven (7) proposals listed in Attachment 2 are disqualified.

We recognize and sincerely appreciate the NAS/NAE's assistance in the evaluation of the SSC site proposals. Please remind your committee and staff of the sensitive nature of the evaluation process and the need to keep your deliberations confidential.

Sincerely,

Jim Decker

James F. Decker
Acting Director
Office of Energy Research

cc:

R. Kasper, NAS/NAE
W. Spindel, NAS/NAE
SSEC Members

SUPERCONDUCTING SUPER COLLIDER SITE PROPOSALS THAT MEET THE QUALIFICATION CRITERIA

Site No.	State	Site Name	Proposer
3	New Mexico	Estancia Basin	State of New Mexico
4	South Dakota	Northern Great Plains	State of South Dakota
6	Montana	Montana Site	State of Montana
7	Nevada	Nevada Site	State of Nevada
8	New Mexico	Dona Ana County	West Texas Council of Govts. & Dona Ana County
9	Wyoming	Cheyenne	State of Wyoming
10	Texas	Far West Texas Site	West Texas Council of Govts.
11	Utah	Ripple Valley	State of Utah
12	Utah	Cedar Mountains Site	State of Utah
13	Florida	Jacksonville	State of Florida
14	Kansas	Topeka	State of Kansas
15	Tennessee	Tennessee Site	State of Tennessee
16	New York	St. Regis Valley Site	State of New York
17	Louisiana	Louisiana Site	State of Louisiana
18	Oregon	Columbia River Site	State of Oregon
19	Arizona	Maricopa	State of Arizona
20	Texas	Amarillo	State of Texas
21	Colorado	Denver Site	State of Colorado
22	Mississippi	Mississippi Site	State of Mississippi
23	Illinois	Fermilab	State of Illinois
24	Oklahoma	Oklahoma Site	State of Oklahoma
25	New York	Wallkill Valley Site	State of New York
26	Texas	Dallas/Fort Worth Site	State of Texas
27	Ohio	Ohio Site	State of Ohio
28	Arizona	Sierrita Site	State of Arizona
29	New York	Rochester Site	State of New York
30	Washington	Lincoln County Site	State of Washington
31	Oregon	University Site	State of Oregon
32	North Carolina	Raleigh/Durham	State of North Carolina
33	Michigan	Stockbridge Site	State of Michigan
34	Alaska	Denali Site	State of Alaska
35	Michigan	Dundee Site	State of Michigan
36	Texas	Garden City Site	Garden City SSC Commission
38	Idaho	Idaho National Engineering Laboratory	State of Idaho
40	California	Davis Site	State of California
41	California	Stockton Site	State of California

ATTACHMENT 1

SUPERCONDUCTING SUPER COLLIDER SITE PROPOSALS THAT DO NOT MEET ONE OR MORE QUALIFICATION CRITERIA

Site No.	State	Site Name	Proposer
1	Texas	Liberty County Site	Terrell G. Lara
2	N/A	Jablonka	Paul Jablonka
5	Washington	Mattawa	A-Enterprises
37	Utah	Delta Area Site	Larsen Institute of Technological Evolution
39	New York	International Site	State of New York
42	Texas	Dever Site 1	O.R. Amy
43	Texas	Devers Site 2	Bill Leatherwood

ATTACHMENT 2

Appendix D
October 26 Letter from Wilmot N. Hess to Edward A. Frieman

October 26, 1987
Dr. Edward A. Frieman
Chairman
Super Collider Site Evaluation
Committee
National Academy of Sciences/
National Academy of Engineering
La Jolla, CA 92093

Dear Dr. Frieman:

On September 18, 1987, we transmitted a listing of SSC site proposals which met the qualification criteria set forth in the Invitation for Site Proposals for the SSC. The purpose of this letter is to inform you that proposal #25 for the Wallkill Valley site has been withdrawn from further consideration by the State of New York. I have enclosed a copy of Governor Cuomo's letter for your information.

Please destroy the copies of the Wallkill Valley proposal that we have sent to you. A complete distribution list of these copies to the SSEC committee and staff is enclosed. We would appreciate your confirmation to us that all of the copies for the Wallkill Valley site have been destroyed.

Thanks so much for your continuing assistance in evaluating SSC site proposals.

Sincerely,

Wilmot N. Hess
Chairman
SSC Site Task Force

Appendix E
Biographical Sketches of Committee Members

EDWARD A. FRIEMAN (Chairman) is director of Scripps Institution of Oceanography and vice chancellor of marine science at the University of California, San Diego.

Dr. Frieman began his career in 1951 as an instructor at Polytechnic Institute of Brooklyn. From 1952 to 1979, he was a professor of astrophysical sciences and deputy director of the Plasma Physics Laboratory at Princeton University. He was with the U.S. Department of Energy as director of energy research from 1979 to 1981. Prior to his appointment at Scripps in 1986, he was executive vice president at the Science Applications International Corporation from 1981. Concurrently, he was an adjunct professor of physics at the University of California, San Diego. Dr. Frieman held a National Science Foundation Postdoctoral Fellowship in 1964 and a John Simon Guggenheim Fellowship in 1970. He has served on numerous government and private sector panels and boards. He is a member of the National Academy of Sciences and the American Association for the Advancement of Science and a fellow of the American Physics Society. His research interests are in plasma physics, hydromagnetics, hydrodynamics, and astrophysics. Dr. Frieman received a B.A in engineering from Columbia University (1946) and an M.A. (1948) and Ph.D. (1953) in physics from Polytechnic Institute of Brooklyn, New York.

ROBERT McCORMICK ADAMS is secretary of the Smithsonian Institution, Washington, D.C.

Dr. Adams was an educator and administrator with the University of Chicago from 1955 to 1984. He was the Howard H. Swift Distinguished Service Professor of Anthropology (1975-1984); director of the university's Oriental Institute (1962-1968 and 1981-1983); dean of the Division of Social Sciences (1970-1974 and 1979-1980); and provost of the university (1983-1984). He also held appointments to the Department of Anthropology and Near Eastern Languages and Civilizations, and the Committee on Public Policy Studies. Dr. Adams assumed the Smithsonian post in 1984. He has lectured at U.S. and foreign institutions and continues to teach, serving as a research associate with the University of Chicago's Department of Anthropology (from 1984) and as adjunct professor with the Departments of Anthropology and Near Eastern Studies at The Johns Hopkins University (from 1984). Dr. Adams is a member of numerous associations and organizations, including the National Academy of Sciences, the American Association for the Advancement of Science, the American Oriental Society, and the Middle East Institute. He is a fellow of the American Academy of Arts and Sciences, the American Anthropological Association, and the Middle East Studies Association. His research interests are in the agricultural and urban history of the Near and Middle East, geographical and archaeological study of settlement patterns, comparative economic and social history of pre-modern societies, and institutions and policies for the support of research. Dr. Adams received a Ph.B. (1947), an A.M. (1952), and a Ph.D. (1956), all from the University of Chicago.

WILLIAM J. BAUMOL is professor of economics at Princeton University, New Jersey, and New York University, New York City.

Dr. Baumol began his career at the U.S. Department of Agriculture (1942-1943, 1946). He was an assistant lecturer at the London School of Economics (1947-1949). He moved to Princeton University, where he advanced from assistant professor (1949) to professor (1954). In 1971 he also became professor at New York University, commencing a joint appointment with both institutions. He is the director of the C.V. Starr Center for Applied Economics at New York University (from 1984). Dr. Baumol is the author of numerous books and publications on economic theory and processes. He is the recipient of the Townsend Harris Medal awarded by the City University of New York; a Guggenheim fellow (1957-1958); and Ford Faculty Fellowship recipient (1965-1966). He is a member of the American

Economics Association, the American Academy of Arts and Sciences, the Atlantic Economic Society, and the American Philosophical Society and a fellow of the Econometric Society. He is a member of the National Academy of Sciences and has honorary degrees and fellowships from U.S. and foreign colleges and universities. He received a B.S.S. from the City College of New York (1942) and a Ph.D. from London University (1949).

JOHN E. CANTLON is vice president at the Michigan State University, East Lansing.

Dr. Cantlon began his career at the George Washington University advancing from assistant professor in botany to associate professor (1950-1953). From 1953 to 1954 he served as senior ecologist at the Physics Research Laboratory of Boston University. In 1954 he moved to Michigan State University and served as associate professor of botany (1954-1958), and professor (1958-1969). In 1969 he was appointed provost, a post he held until 1975, when he moved to his current position. Dr. Cantlon has served on many advisory panels and committees with the National Academy of Sciences, the National Science Foundation, the American Institute of Biological Sciences, the Department of Defense, the Oak Ridge National Laboratory, the Department of Energy, and the Environmental Protection Agency. He is a member of the American Association for the Advancement of Science, the American Institute of Science, the Ecological Society of America, the Botany Society of America, and the American Society of Naturalists. His research interests are in physiological ecology, patterns in communities, Alaskan tundra vegetation, and research and academic administration. Dr. Cantlon received a B.S. from the University of Nevada (1947) and a Ph.D. in botany from Rutgers University (1950).

LLOYD S. CLUFF is manager of the Geosciences Department, Pacific Gas and Electric Company (PG&E), San Francisco, California.

Mr. Cluff began his career with El Paso Natural Gas Company as junior geologist (1957-1959), then with the firm of Lottridge Thomas & Associates (1960). He joined Woodward-Clyde Consultants in 1960, advancing from staff geologist to associate and chief engineering geologist, vice president, principal and director. He joined PG&E in 1985. Mr. Cluff has served on numerous international and national consulting boards and advisory panels, including those of the National Academy of Sciences, the U.S. Geological Survey, National Academy of Sciences, the U.S. Geological Survey, the National Science Foundation, the International Atomic Energy Agency, the California Seismic Safety Commission and Governor's Earthquake Council, and others, advising on the siting of critical facilities from the standpoint of engineering geology and seismic safety. In 1965, he was presented the Hogentogler Award by the American Society of Testing and Materials. Mr. Cluff is a member of the National Academy of Engineering, Association of Engineering Geologists (president, 1968-1969), Earthquake Engineering Research Institute (director, 1976-1980), International Association of Engineering Geologists, Seismological Society of America (president, 1982-1983), Structural Engineers Association of Northern California, and Geological Society of America. His research interests are in active faults, earthquake and geologic hazards, seismic safety, and engineering geology. Mr. Cluff received a B.S. in geology from the University of Utah (1960).

ERNEST D. COURANT is a senior physicist at Brookhaven National Laboratory in Upton, New York.

Dr. Courant was a graduate student at the University of Rochester from 1940 to 1943; he left to take a position as scientist at the Atomic Energy Project of the National Research Council of Canada (1943-1946). He was a research associate in physics at Cornell University (1946-1948), and joined the Brookhaven National Laboratory when the laboratory was founded in 1947. He has remained there since, rising to the rank of senior physicist in 1960. He has held concurrent university appointments at Princeton University as assistant professor (1950-1951); Yale University as Brookhaven professor of physics (1962-1967); SUNY-Stony Brook as professor of physics and engineering (1967-1985). He served as a consultant to the General Dynamics Corporation (1958-1959) and as a visiting physicist at the National Accelerator Laboratory (1968-1969). Dr. Courant is a co-originator of strong-focusing particle accelerators. He is a fellow of the American Physical Society and the AAAS, and a member of the National Academy of Sciences and the New York Academy of Sciences, from which he received the Boris Pregel Prize in 1979. He received the Fermi Prize (1986) and the R. R. Wilson Prize (American Physical Society, 1987). His research interests include particle accelerators, nonlinear dynamics, and nuclear reactions. Dr. Courant received a B.A. from Swarthmore College (1940), and an M.S. (1942) and Ph.D. (1943) in physics from the University of Rochester.

DON U. DEERE is an international consultant in engineering geology and rock mechanics from Gainesville, Florida, and an adjunct professor of civil engineering at the University of Florida.

Dr. Deere began his career in mining engineering, first with Phelps Dodge Corporation in Arizona (1943-1944) and then with Potash Company of America in New Mexico (1944-1946). He became assistant professor and then associate professor of civil engineering at the University of Puerto Rico (1946-1950) and became head of the Department of Civil Engineering (1950-1951). He was co-founder and partner of the Foundation Engineering Company of Puerto Rico (1951-1955). He returned to teaching at the University of Illinois at Champaign-Urbana, where he had a joint appointment in the departments of civil engineering and of geology, and where he advanced from associate professor to professor (1955-1972). In 1972 he moved to Gainesville, Florida, and became a full-time consultant on dams, tunnels, and landslides, mostly overseas. He also is an adjunct professor in civil engineering at the University of Florida. Dr. Deere is a member of the National Academy of Engineering, National Academy of Sciences, República Argentina *Academia Nacional Ciencias Exactas, Fisicas, y Naturales (Académico Correspondiente)*, American Society of Civil Engineers, Geological Society of America, and Association of Engineering Geologists. He received the MOLES Award in 1983 for Outstanding Achievement in Construction. Dr. Deere received a B.S. in mining engineering from Iowa State College (1943), an M.S. in geology from the University of Colorado (1949), and a Ph.D. in civil engineering from the University of Illinois (1955).

THOMAS E. EVERHART is president of California Institute of Technology, Pasadena.

Dr. Everhart began his career at the Research and Development Laboratories at Hughes Aircraft Company (1953-1955). He was a member of the Department of Electrical Engineering and Computer Science at the University of California, Berkeley, from 1958 to 1978. He was department chairman from 1972 to 1977. Dr. Everhart was dean of the College of Engineering and professor of electrical engineering at Cornell University (1979-1984), and chancellor and professor of electrical and computer engineering at the University of Illinois at Urbana-Champaign (1985-1987). He has served on numerous advisory boards and as a consultant. Dr. Everhart was a Marshall Scholar at Cambridge University (1955-1958); held a National Science Foundation Senior Post-doctoral Fellowship (1966-1967); was a Miller Research Professor at the University of California, Berkeley

(1969-1970); and held a John Simon Guggenheim Fellowship (1974-1975). He is a member of the National Academy of Engineering, Institute of Electrical and Electronic Engineers, and American Association for the Advancement of Science. Dr. Everhart received an A.B. in physics from Harvard (1953), an M.Sc. in applied physics from the University of California, Los Angeles (1955), and a Ph.D. in engineering from Cambridge University, England (1958).

MARVIN L. GOLDBERGER is director, Institute for Advanced Study, Princeton, New Jersey.

Dr. Goldberger began his career as a physicist at the Radiation Laboratory at the University of California (1948-1949). He was a research associate in physics at Massachusetts Institute of Technology (1949-1950), and at the University of Chicago he advanced from assistant professor to professor of physics (1950-1957). He moved to Princeton University, where he was appointed the Higgins Professor of Mathematical Physics (1957-1977); chairman of the Physics Department (1970-1976); and the Joseph Henry Professor of Physics (1977-1978). He was president of the California Institute of Technology from 1978 to 1987. Concurrently, he served as the Higgins Visiting Associate Professor (1953-1954); member, President's Science Advisory Committee (1965-1969); and member, Council on Foreign Relations. In 1961 he was awarded the Dannie Heineman Prize. Dr. Goldberger is a member of the National Academy of Sciences, American Physical Society, American Academy of Arts and Sciences, American Philosophical Society, and Federation of American Scientists. He is a director of General Motors. His research interest is in theoretical high-energy physics. Dr. Goldberger received a B.S. from the Carnegie Institute of Technology (1943) and a Ph.D. in physics from the University of Chicago (1948).

WILLIAM R. GOULD is the chairman emeritus of Southern California Edison Company in Rosemead.

After seven years of service as an engineer officer in the U.S. Navy, Mr. Gould continued his engineering career in the electric utility industry. In 1948 he joined the Southern California Edison Company as a mechanical engineer and advanced through the ranks until becoming president of the company in 1978. In 1980 he was elected chairman of the board and chief executive officer, from which position he is now retired. He served the industry in many committee and association assignments, including several years as chairman and CEO of The Electric Power Research Institute and chairman and

CEO of the Atomic Industrial Forum. He has served as a fellow and chairman, Institute of Advanced Engineering; member and president (U.S.), International Conference on Large High Voltage Electrical Systems; member, U.S. Energy Research and Development Administration general advisory committee. He is the recipient of the Power-Life Award of the Institute of Electrical and Electronics Engineers (1978), the George Westinghouse Gold Medal of the American Society of Mechanical Engineers (1979), and the Oliver Townsend Medal of the Atomic Industrial Forum (1985). He is a member of the National Academy of Engineering and a fellow of the American Society of Mechanical Engineers. His research interests include mechanical engineering, electrical engineering, nuclear engineering, and electric power generation, transmission, and distribution. Mr. Gould received a B.S. from the University of Utah (1942) and was awarded a Naval Architecture Diploma from MIT in the U.S. Navy postgraduate program.

LTG ELVIN R. HEIBERG, III, is chief of engineers, U.S. Army Corps of Engineers, Washington, D.C.

General "Vald" Heiberg was commissioned a 2nd lieutenant in the U.S. Army in 1953 and advanced to lieutenant general in 1984. He served with the Corps of Engineers in New Orleans (1974-1975) and in Cincinnati (Ohio River Division (1975-1978)). He then was engineer, U.S. Army, Europe (1978-1979); director of civil works, Washington, D.C. (1979-1981); deputy chief of engineers (1981-1983); and program manager, Ballistic Missile Defense Program (1983-1984). He was on the faculty of the U.S. Military Academy from 1965 to 1968. Active duty assignments earlier included service in Korea, Germany, and Viet Nam. General Heiberg has been awarded the Distinguished Service Medal, Silver Star, and a number of other U.S. and foreign decorations. He is a member of the American Society of Civil Engineers and national president of the Society of American Military Engineers. LTG Heiberg received a B.S. from the U.S. Military Academy (1953), an M.S. in civil engineering from Massachusetts Institute of Technology (1958), an M.A. in government (1961), and an M.S. in administration (1971) from George Washington University. He became the 46th Chief of Engineers in 1984, a four-year assignment, after Senate confirmation of President Reagan's nomination.

EDWARD G. JEFFERSON, chairman and chief executive officer (retired); member, Board of Directors, and chairman, Finance Committee, of the Du Pont Company, Wilmington, Delaware.

Dr. Jefferson joined Du Pont in 1951 and advanced through a series of supervisory positions. In 1973 he was appointed a director, senior vice president, and member of the Executive Committee. In 1978 he was given responsibility for the direction and coordination of all research and development activities for the company. He was named president and chief operating officer in 1980, and became chairman and chief executive officer in 1981. Dr. Jefferson was awarded the Samuel Smiles Prize for Chemistry from King's College, University of London. He is a member of the National Academy of Engineering and the American Philosophical Society and a fellow of King's College. He holds a doctoral degree from King's College, University of London.

HERMAN B. LEONARD is the George F. Baker, Jr., Professor of Public Sector Financial Management, John F. Kennedy School of Government, Harvard University.

Dr. Leonard began his career as an educator as the assistant head tutor in economics at Harvard University (1975-1979); assistant professor of public policy (1979-1983); and associate professor of public policy (1983-1986). He assumed his present position in 1986. He was a National Science Foundation Graduate Fellow in Economics (1974-1979), Harvard University Junior Fellow (1976-1979), and Faculty Research Fellow, National Bureau of Economic Research (from 1983). Dr. Leonard currently serves on the National Academy of Sciences Committee on National Urban Policy, Senate Budget Committee Private Sector Advisory Committee on Infrastructure, and is chairman of the Massachusetts Governor's Task Force on Tuition Prepayment Plans. His research interests include public finance and public financial management, and his teaching closely parallels those interests by focusing on policy analysis, finance and financial management, and financial control. Dr. Leonard received an A.B. (1974), A.M. (1976), and Ph.D. (1979), all from Harvard University.

WALTER E. MASSEY is the vice president for research at the University of Chicago and vice president of Argonne (Illinois) National Laboratory.

Dr. Massey began his career as a physicist with the Argonne National Laboratory (1966-1968). He was assistant professor of physics at the University of Illinois, Champaign-Urbana (1968-1970); associate professor (1970-1975), professor, and dean, Brown University, Providence (1975-1979). He was appointed director of Argonne National Laboratory (1979-1984). Concurrently, he was named vice president for research at the University of Chicago (1982). In 1984 he was named vice president of Argonne. He was a National Science Foundation fellow (1962), a National Defense Education Act fellow (1959-1960), and an American Association for the Advancement of Science fellow. He is a member of the National Science Foundation, American Physics Society, and American Association of Physics Teachers. Dr. Massey received a B.S. from Morehouse College (1958), and an M.A. (1966) and Ph.D. (1966) from Washington University, St. Louis.

PAUL J. REARDON is vice president and director of experimental projects, Science Application International Corporation, Princeton, New Jersey.

Mr. Reardon's career included responsibilities as a physicist at the Johns-Manville Research Center (1954-1956); head of synchrontron operating, Division of Accelerator Physics, Princeton University (1956-1964); accelerator physicist, High-Energy Physics Section, Division of Research, U.S. AEC (1964-1966); research physicist, accelerator physics and project manager, Bates Linear Accelerator Laboratory of Nuclear Science, Massachusetts Institute of Technology (1966-1969); senior physicist and associate laboratory director of accelerator physics, Fermi National Accelerator Laboratory (1968-1975); head, Booster Synchrontron Section (1968-1970); director, business administration (1969-1972); head, Energy Doubler Section (1972-1974); associate laboratory director and head, Accelerator Division (1972-1975); project manager, Tokamak Fusion Test Reactor (1975-1978); associate director and head, Department of Technology, Plasma Physics Laboratory, Princeton University (1978-1982). Mr. Reardon has also served as a consultant and member of advisory panels and committees, including the Positron Policy Committee, University of California and Stanford University (1976-1980); Lawrence Berkeley Laboratory Accelerator and Fusion Research Review Committee (1977-1979); and Fermilab Review Committee (1977-1979). He is an American Physics Society fellow. His research interests are in plasma physics, design, construction, management, operation and research, exploration of large particle accelerators and fusion research devices. Mr. Reardon received an A.B. from Boston College (1952) and an M.S. from Rutgers University (1960).

NICHOLAS P. SAMIOS is director of the Brookhaven National Laboratory in Upton, New York.

Dr. Samios's career began as an instructor of physics at Columbia University (1956-1959). He moved to Brookhaven National Laboratory, where he advanced from assistant physicist to senior physicist (1959-1968). He was group leader (1965-1975), chairman of the Physics Department (1975-1981), and deputy director for High Energy and Nuclear Physics (1981). He assumed his current position in 1982. Concurrently, he was adjunct professor at Stevens Institute of Technology (1965-1975) and Columbia University (from 1970). Dr. Samios is the recipient of the E.O. Lawrence Memorial Award (1980) and the Physics and Math Science Award, New York Academy of Science (1980). He is a member of the National Academy of Sciences and a fellow of the American Physics Society and American Academy of Arts and Sciences. His research interests are in high-energy particle and nuclear physics. Dr. Samios received an A.B. (1953) and Ph.D. in physics (1957) from Columbia University.

ROY F. SCHWITTERS is professor of physics at Harvard University.

Dr. Schwitters began his career at the Stanford University Linear Accelerator Center as research associate (1971-1974) and advanced to associate professor of experimental high-energy physics (1974-1979). In 1979 Dr. Schwitters assumed his present position as professor of physics at Harvard. He has also been doing research at the Fermi (Illinois) National Accelerator Laboratory since 1980. Since 1978 he has been an associate editor of the *Annual Review of Nuclear and Particle Science.* He is the recipient of the National Science Foundation's Alan T. Waterman Award (1979). He is an American Physics Society fellow and a member of the American Association for the Advancement of Science. Dr. Schwitters received a S.B. (1966) and Ph.D. in physics (1971) from the Massachusetts Institute of Technology.

CHARLES H. TOWNES is a professor of physics at the University of California, Berkeley.

Dr. Townes's career began as a physics assistant at the California Institute of Technology (1937-1939). He was a member of the technical staff at the Bell Telephone Laboratories from 1939 to 1947. He moved to Columbia University, where he advanced from associate professor to professor of physics (1948-1961). He was the executive director of the Radiation Laboratory (1950-1952) and was chairman of the department from 1952 to 1955. From 1961 to 1967 Dr. Townes continued his career at the Massachusetts Institute of Technology as Provost and professor of physics. He assumed his current position at the University of California, Berkeley, in 1967. Dr. Townes has lectured at U.S. and foreign institutions and has served on numerous advisory committees and panels, including the NASA science and technology advisory committee on manned space flight (1964-1969); President's Science Advisory Committee (1966-1970); President-Elect's Task Force on Space (1968); President's Task Force on National Science Policy (1969); and the Committee on Scholarly Exchanges with the People's Republic of China (1979). He won the Nobel Prize in Physics (1964); the Comstock Award, National Academy of Sciences (1959); the Earle K. Plyler Prize, American Physics Society; and the Niels Bohr International Gold Medal. He was an Adams fellow (1950); a Guggenheim fellow (1955-1956); and a Fulbright lecturer, Paris (1955-1956) and Tokyo (1956). He is a member of the National Academy of Sciences, Royal Society of London, and American Astronomy Society and a fellow of the American Physics Society. His research interests are in molecular and nuclear structure, masers, lasers, radio and infrared astronomy, microwave spectroscopy, optics, and quantum electronics. He has twenty-one honorary degrees from U.S. and foreign universities and colleges. He received a B.A. and B.S. from Furman University (1935), an M.A. from Duke University (1937), and a Ph.D. in physics from California Institute of Technology (1939).

VICTORIA J. TSCHINKEL is senior consultant with the law firm of Landers, Parsons and Uhlfelder in Tallahassee, Florida.

Ms. Tschinkel began her career in environmental work with teaching and research positions. In 1974 she joined the Florida Trustees of the Internal Improvement Trust Fund as a field inspector. In 1975 she joined the newly reorganized Florida Department of Environmental Regulation as an Environmental Specialist. She advanced within the department, where she served as assistant to the secretary, acting secretary, and assistant secretary. In 1981 she was appointed secretary of the department by Governor Bob Graham. Under her leadership, Florida made several landmark initiatives in water quality protection, including a complete rewrite of the state's water quality standards, adoption of a state water policy, and comprehensive revisions to the state's groundwater protection rules. She has served on numerous state and national advisory boards and committees, including appointments to the U.S. Department of Energy Advisory Board and an Environmental Protection Agency advisory panel on toxic pollutants. Ms. Tschinkel received an A.B. in zoology from the University of California, Berkeley (1968).

STEVEN WEINBERG is the Josey Professor of Science at the University of Texas, Austin.

Dr. Weinberg's career began at Columbia University as an instructor of physics (1957-1959). He moved to the University of California, Berkeley, where he was a research associate in the Lawrence Radiation Laboratory (1959-1960). From 1960 to 1969, he advanced from assistant professor to professor of physics. He continued his career as professor at the Massachusetts Institute of Technology from 1969 to 1973. He was appointed Higgins Professor of Physics at Harvard University in 1973. He assumed his current position at the University of Texas in 1982. Dr. Weinberg has served on consulting and advisory panels and committees and has lectured at U.S. and foreign institutions. He was awarded the Nobel Prize in Physics (1979); the Elliott Cresson Medal, Franklin Institute (1979); and the J.R. Oppenheimer Prize, University of Miami (1973); and was a Sloan Foundation fellow (1961-1965). Dr. Weinberg holds numerous honorary degrees. He is a member of the National Academy of Sciences, American Academy of Arts and Sciences, American Physics Society, American Astronomy Society, and Royal Society of London. His research interests are in elementary particles, field theory, and cosmology. Dr. Weinberg received an A.B. from Cornell University (1954) and a Ph.D. in physics from Princeton University (1957).

STANLEY G. WOJCICKI is professor of physics at Stanford University and deputy director of the Superconducting Supercollider Central Design Group, Berkeley, California.

Dr. Wojcicki began his career as a physicist at the Lawrence Radiation Laboratory, Berkeley (1961-1966). He continued his career at Stanford University, where he advanced from assistant professor to professor of physics (1966-1974). He was chairman of the Physics Department from 1982 to 1985. Concurrently, he served as chairman of the Stanford Linear Accelerator Center Experimental Program Advisory Committee (1979-1981). Since 1984 he has served as deputy director of the Superconducting Supercollider Central Design Group. He is a recipient of the Alexander von Humboldt Senior American Scientist Award (1981); a National Science Foundation fellow (1964-1965); a Sloan Foundation fellow (1968-1972); and a Guggenheim fellow (1973-1974). He is also an American Physics Society fellow. His research interests are in resonances in high-energy physics, CP violation, rare K meson delays, electron-positron annihilations, and muon production in hadronic interactions. Dr. Wojcicki received an A.B. from Harvard University (1957) and a Ph.D. in physics from the University of California, Berkeley (1962).

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